Report

National Brucellosis Technical Commission

R. K. Anderson
David T. Berman
W. T. Berry
John A. Hopkin
Robert Wise

Appendix B

Benefit-Cost Analysis

By

Stephen H. Amosson, Raymond A. Dietrich and John A. Hopkin*

for

U. S. Animal and Plant Health Inspection Service

and

United States Animal Health Association

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(*Authorship is shared equally)

Appendix B

BENEFIT/COST ANALYSIS

CHAPTER I: INTRODUCTION

One of the primary charges to this Commission was to "make an economic benefit/cost analysis of the present national bovine brucellosis eradication program with its proposed extensions, and any alternative programs which the Commission deems appropriate." The benefit/cost ratio is designed to estimate the dollars of benefits which are expected per dollar of total expenditures on the program. These ratios for alternative programs of brucellosis control and/or eradication can than be compared with one another and with ratios for expenditures in other investment opportunities to establish priorities among policy alternatives.

Two basic techniques are available for aggregating the economic data which determine the benefit/cost ratio--the partial budgeting technique and systems simulation. With partial budgeting attempts are made to identify and estimate the added benefits and costs to be accrued within a defined population as a consequence of specified alternative actions. This technique has serious limitations as an analytical system for policy issues and was used in this report only for illustrative purposes. Instead, a systems simulation model was used in making our benefit/cost analysis.

Systems simulation attempts to more adequately model a simplified version of the real world in order to better assess the impact of alternative actions on the total system. In so doing, it makes a very important contribution to the analysis of difficult problems involving the economic implications of complex interactions of both biologic and engineering systems. As a caveat, however, it should be stressed that all systems simulation models must, of necessity, make simplifying assumptions, and represent abstract versions of the real world. There remains a very large gap between the theoretical manipulations of disease models and the application of models to specific diseases, especially on a large scale. They should not, therefore, be the only basis upon which policy decisions are based.

Prior Benefit Cost Studies of Brucellosis

I. One of the first major benefit/cost studies of brucellosis was published by the University of Reading, England, in 1975: An Assessment of the Eradication of Bovine Brucellosis in England and Wales, by M. E. Hugh-Jones, P. R. Ellis and M. R. Felton; Study No. 19. The biological dimensions of this study were based on a stochastic computer simulation of brucellosis infection in a 100 herd model rep resenting dairy and beef herds of England and Wales. Disease spread was simulated using a Monte Carlo random number technique with probability ranges deemed epidemiologically relevant.

The basic decision-making unit for their model was the dairy or beef herd. The herd consisted of three streams of animals: (1) healthy (normal in every way); (2) infected (appear normal but have been

infected, although they do not show a serological response); and (3) reactor (serological and legal reactors). The time interval for disease spread was three weeks, corresponding to the estrus cycle. The herd was modeled with three sets of arrays--for calves, heifers and cows. Calves were transferred to heifers upon pregnancy and heifers transferred to cows upon calving.

Using representative alternative herd management assumptions within the model, the computer assessed and monitored infection spread, clean up and physical losses of milk and beef. The physical losses of beef and milk were then estimated for all the herds of England and Wales. These losses were then used to compute marginal differences in producer profits associated with each category of physical loss. The loss categories and methods of specification were as follows:

<u>For dairy herd</u>

1. Aborted calves at £20 per calf.

2. Milk loss from aborting cows kept in herd (one-half the aborting cows) figured at 50 percent of the lactation--450 gallons or £93.31 per cow.

3. Milk loss from aborting cows culled from herd (one-half aborting cows) figured at 10 percent of the lactation or 150 gallons of milk plus 50 percent of milk cow value or £60.44 per cow.

4. 63 days delay in conception following an infected calving at 37p per day.

5. Depressed milk yield in 2 percent of infected cows of 10 percent of the lactation.

6. Additional costs for replacement at £1.80 per aborting animal and £0.60 per non-aborting reactor.

<u>For beef herd</u>

1. Infertility due to infection increases the number of "empty" cows by 2.75 percent at £1.20 per cow.

2. Overall effect of increasing the calving interval by 72 days for reacting non-aborting cows which are retained in the herd at £0.11 per day.

3. Decrease in live calves born of 0.5 per 100 cows at £1.13 per calf.

4. Difference in growth performance of calves born to reacting mothers (weak calves) of 0.01 lbs. of gain per day at £12.97 per lb.

5. Increased replacement costs at £0.73 per cow.

The overall benefit/cost ratio for the British Brucellosis Compulsory Eradication Scheme for England and Wales was estimated at a low of 1.1 to 1 to a high 2.2 to 1, depending on the inclusion of losses which are very difficult to quantify, such as the human health hazard, the risk of abortion storms, constraints on trade and exports and unrealized production potential.

II. In 1975, also, the California Department of Food and Agriculture released their study: A Report of the Bovine Brucellosis Eradication Program in California, Sacramento, California 1975, conducted by T. E. Carpenter.

This study used a partial budgeting technique for projecting the benefits and costs of three alternative courses of action for the State of California with respect to brucellosis: (1) no program, (2) a control program based heavily on calfhood vaccination and control of movement into the state, and (3) an eradication program. Their basic methods of calculation and assumptions are evident in the following calculations for the beef and dairy industries of the state for fiscal year 1976.

The planning horizon for the comparison was 15 years--from 1976 through 1990. Under option 1 (no program) infection was projected to reach 11.64 percent of the cow (dairy and beef) population by 1990. Under the control program, infection was projected to level off at 1.4 percent of the cow herd. The eradication program was assumed to achieve a zero level of infection within 10 years and to remain free of the disease thereafter. Based on the present value of the flow of benefits and costs and using a discount rate of 9.479 percent (the rate then used by the California Department of Water Resources) the benefit/cost ratios for both the control and eradication programs were favorable--5.07 to 1 and 3.82 to 1 respectively.

Beef

Population (No. of beef cows)	1,085,400	
Prevalence rate	x .0014	
	1,520	
Cull rate due to brucellosis infection	x .15	
	228	
Replacement cost	x $213.39	
		$48,653
Reactors slaughtered	x .17*	
	258	
Replacement cost - Idemnity ($213.39) - ($119.54)	x $93.85	
		$24,213

Continued

*17% assumes 20% of the remaining infected (85%) will be found blood test positive.

Remaining infected cows	1,034	
	x .18*	
Infected - vaccinates (@ 38% susceptibles vaccinated	180	
Abortion rate	x .15	
	28	
Infected non-vaccinated	848	
Abortion rate	x .21	
	178	
Total calves aborted	206	
Value/calf	x $50	
		$10,300
Total losses		$83,166

*Percent calculated assuming nonvaccinated animals are 2.86 times more susceptible to infection than vaccinated animals: $\frac{(2.86)}{(\ 1\ )}\ \frac{(.62)}{(.38)}$

Therefore, infection ratio of $\frac{\text{vaccinated animals}}{\text{nonvaccinated animals}} = \frac{1}{4.66}$. This

means the percent of infected vaccinated animals accounts for $\frac{1}{5.66}$ or 18% of the infected animals.

Dairy

Population (No. of dairy cows)	800,000	
Infection Rate	x .0024	
	1,920	
Cull rate due to brucellosis infection	x .15	
	288	
Replacement Cost	x $532.81	
		$153,449
Remaining infected cows found 6 months later to be reactors	1,632	
Replacement costs - Idemnity ($532.81) - ($222.31)	x $310.50	
		$506,736
Expected annual milk production (cwt)	136.09	
180 days/305 day lactation period	x .59	
Production for 6 months (cwt)	80.29	
	x 1,632	
Total expected milk production for 6 months (cwt)	131,033	
Production decrease due to brucellosis infection	x .20	
	26,207	

Continued

Value of milk (cwt)	x $8.04*	
Value of annual milk loss		$210,704
Total losses		$870,889

*Producer price, F.O.B. plant, (equivalent cwt.)
Class 4 milk, (September, 1975)

III. An Australian brucellosis simulation model was developed beginning in 1973, and was the basis for more detailed studies of eradication policies and for estimating costs and benefits of proposed eradication programs. Although the model and study have not been published, some results have been reported.[1]

The model is designed to simulate range conditions, herd structure, and livestock population characteristics for any designated region. The model simulates the dynamics of both the cattle population and Brucella abortus by feeding into the model a 10 percent sample of the animals in a given geographic area. Each cow is individually represented in the model relative to (1) vaccination status; (2) infection status (infection is programmed to occur according to defined probabilities); (3) serological status; and (4) age. The age of each animal is recorded and each iteration adds one year to each animal. While the serological response and infection status are highly correlated, the model permits these two features to be inconsistent--as false negative or false positive.

The model divides the epidemiological behavior of brucellosis into a sequence of events, each of which is selected by the computer based on a random number, Monte Carlo simulation.

The cattle population was specified relative to: (1) number of herds; (2) proportion of beef and dairy herds; (3) herd size structure; (4) culling rates; (5) reproductive performance; (6) initial disease prevalence; and (7) percent of herd vaccinated. Other inputs included (1) probability of new infection and abortions, (2) commencement of a test and slaughter program, and

[1]Roe, R. T. and R. S. Morris, "The Integration of Epidemiological and Economic Analysis in the Planning of the Australian Brucellosis Eradication Program," in New Techniques in Veterinary Epidemiology and Economics Proceedings of the Symposium, University of Reading, England, July 12-15, 1976, pp. 81-94.

(3) other constraints relative to total numbers, monies available for compensation, etc. The model then determined for each individual cow whether: (1) she calves, aborts or remains non-pregnant; and (2) she becomes infected and/or changes her serological status, etc.

Benefits of disease control were estimated to be due to reduction in such physical losses as milk production, calf production and incidence of placental retention. More importantly, significant benefits were attributed to the maintenance of high-price export markets for Australian beef. It was assumed that these markets would be lost when other countries achieved freedom from brucellosis, unless the Australian eradication program proceeded on a similar time schedule to the program in the importing countries. Rough estimates were also made of the public health benefits which would accrue from control measures. Net present values of various strategies were estimated for a 30-year period, using a 10 percent discount rate. The test and slaughter eradication program produced an overall benefit/cost ratio of 5.04 compared to a benefit/cost ratio of 2.96 for a continuing vaccination program. The authors also stated that, "Although this study produced interesting results, many of the estimates were based on somewhat tenuous evidence, since the information available for estimating benefits of brucellosis control is very scarce and is frequently of questionable validity."

IV. In February, 1977, APHIS, USDA published their study Brucellosis Program Analysis by Beale, V. C., Jr., H. A. Kryder, Jr. and B. R. McCallon. This study was based on a computer simulation model of the U. S. beef and dairy industries, with five regional subdivisions. The model inputs included the following items for each region: (1) herd size and number of herds; (2) average number of cows/herd (1975); (3) distribution of infected herds by year of infection; (4) infection rates; (5) cull rate; (6) clean-up rates (probability of clean-up depending on program); (7) regional purchase probability vs. purchase of replacements outside of region; (8) fence spread factor; (9) probability of infected herd being detected through MCT and BRT; and (10) a regional test factor which reflected the effort put forth by producers, governmental agencies and others in combating brucellosis.

The regional physical loss coefficients associated with these inputs for different control and eradication programs were based on data available within APHIS, augmented by judgements of APHIS regional epidemiologists, cattle disease staff members, and the authors. The basic analytical unit was the beef or dairy herd, with eight different herd sizes. Using a deterministic simulation (versus Monte Carlo) model, annual physical losses associated with program alternatives were projected by years starting in 1976 and continuing for 35 years, holding breeding and dairy herds constant.

Production losses were given values as follows:

For dairy cattle:

(1) Production per infected cow was reduced 20%, reducing income by $143.95 per infected cow.

(2) Increased replacement costs of $133.55 per infected cow that was culled due to the disease.

(3) Dead calf losses due to abortion were figured at $60.75 per calf lost.

For beef cattle:

(1) Increased replacement costs were calculated at $27.50 per cow culled because of brucellosis.

(2) Loss of calves due to abortion valued at $133.10 per calf lost.

(3) A 100 lb. growth weight loss of calves from infected mothers, valued at $35.52.

(4) A six month delay in rebreeding of 50% of the cows classified as hard breeders retained in the herd was translated into a loss of $33.27 per delayed breeding cow. Five to nine percent of the infected cows were categorized as being hard breeders.

The final economic loss depended upon the proportion of cows infected, the number of abortions, etc. which they varied by regions, by year of infection and by type of program.

The benefit/cost ratios calculated on the streams of benefits and costs, discounted to the present value using a 10 percent discount rate include:

Program Comparison	Benefit/Cost Ratio
1. 10-year eradication program vs. no program	10.67
2. 10-year eradication program vs. farmers vaccination program	8.65
3. 10-year eradication program vs. reduced level of federal program	3.39
4. 10-year eradication program vs. present program (FY 1975-76) level	1.68
5. Present program vs. no program	8.15
6. Present program vs. reduced level federal	2.36
7. Reduced level federal program vs. no program	7.34

CHAPTER II: THE COMMISSION'S ANALYTICAL MODEL

Each of the models used in the four studies reviewed in Chapter I has some advantages and disadvantages as a basic model with which to make comparisons necessary for meeting the charge given to the Commission. After careful consideration of all relevant factors the Technical Commission selected a systems simulation rather than a budgeting model as the framework of its benefit/cost analysis.

Moreover, the basic model developed was patterned, in part, upon the APHIS, USDA model, but with several important modifications:

(1) The states were divided into eight regions (as outlined below in Figure 1) compared to five for the APHIS model. These regions were grouped on the basis of their similarity with respect to several criteria relating to brucellosis, such as level of infection, herd-size distribution, methods of operation, and effectiveness of brucellosis infection surveillance and control.

(2) The computer sequence and procedures (as paid out schematically in the flow chart comprising Figure 2), differed from the APHIS model.

(3) Many of the epidemiologic coefficients and assumptions differed significantly from those used in the APHIS model. A detailed description of the simulation model, the data inputs and estimating procedure for deveoping these inputs are discussed in Annex 1.

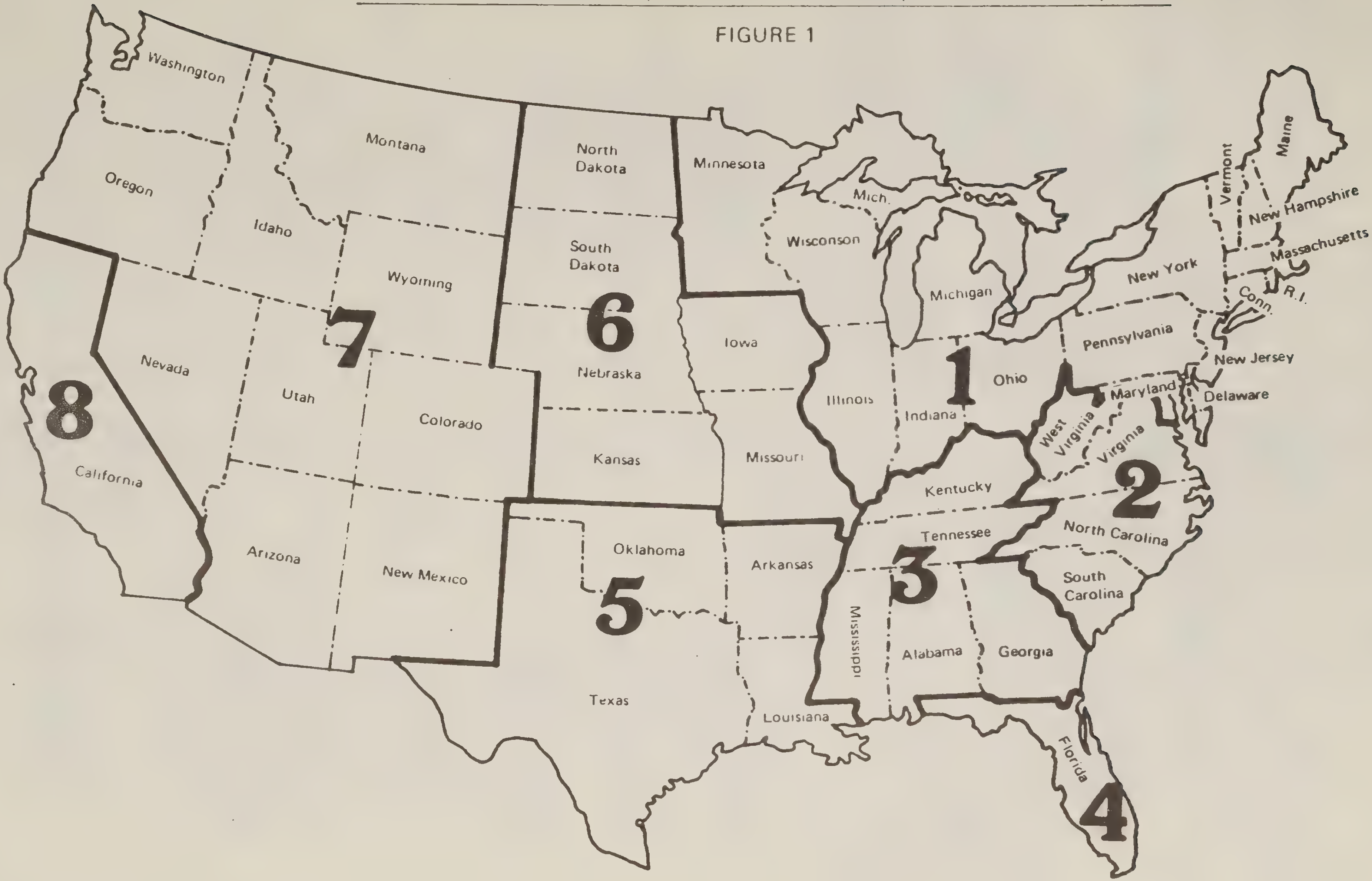
Some of the problems of selecting appropriate input coefficients for systems modeling of bovine brucellosis was described in 1975 by Hugh-Jones as follows:

> "During the construction of the model it was found that although there is a large volume of excellent laboratory data, especially in relation to vaccination and serology, and information from field experience, only a few of the appropriate quantitative observations have been made on the epizootiology of brucellosis. The development of such a model should therefore parallel the development of field studies in order to secure answers to questions raised by the model to clarify problems encountered in the field."

Determining the appropriate physical loss coefficients associated with varying levels of alternative program inputs by regions, herd size, year of infection, etc., is, in the final analysis, a limiting factor in a simulation model of a complex disease such as brucellosis. Unfortunately, the Commission had neither the time nor resources to develop field studies to accompany the model. Program data as presently reported

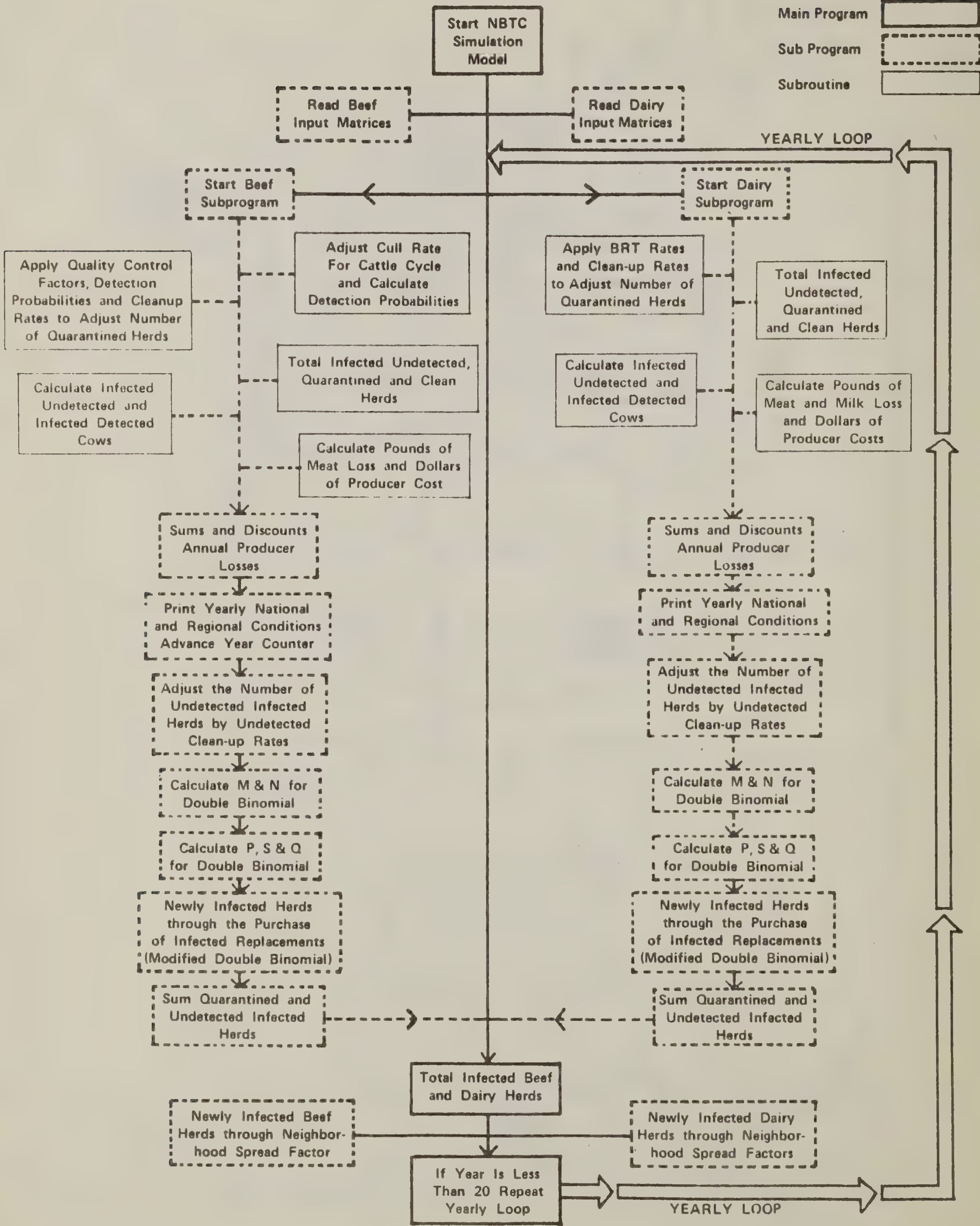
REGIONAL DEMARCATION, BRUCELLOSIS STUDY, UNITED STATES, 1978.

FIGURE 1



NATIONAL BRUCELLOSIS SIMULATION MODEL

FIGURE 2



by the states and compiled by APHIS staff are not adequate for the derivation of accurate coefficients for a simulation model. Hence, although the Commission was unable to completely restructure the field data, an extensive sampling of program data from one or more states in each of the model areas was undertaken. By questionnaire and direct telephone contact with each of the regional epidemiologists, several station epidemiologists, state veterinarians, or state program supervisors significant items were collected. These included:

(1) Within herd infection rates on initial herd test and cumulative rates over the duration of quarantine period. The data were collected according to herd size and percentage vaccination within the herd. Infection rates for vaccinated and unvaccinated animals within the herds were calculated.

(2) Data on length of time between inital test and release from quarantine and total number of herd tests required, by herd size and amount of vaccination, were assembled for derivation of coefficients on vaccine effect and clean up rates.

(3) Results of epidemiologic traces in each of the regions to determine relative importance of several modes of new introductions into previously free herds such as neighborhood spread, adjacent herd contact or fence spread, and purchase. In addition, extensive data were assembled on apparent residual infection, following release from quarantine.

(4) Cross comparisons were made between APHIS staff calculations on MCI identification tracebacks and testing and data from the local sources.

(5) Cross comparisons were made between local and APHIS compiled reported data on calfhood vaccination rates and the amount of herd infection not disclosed in a timely manner by surveillance.

In addition, the in-depth program analysis of 12 states given in detail in Appendix D, and the survey of all 50 state veterinarians in Appendix E furnished important data for derivation of model coefficients.

As a part of the information gathering process, a detailed questionnaire relating to operations, management practices and costs were mailed to a random sample of beef and dairy producers in selected states representing each of the eight regions of the United States outlined in Figure 1. A copy of each of these questionnaires (beef and dairy) is shown in Annex 2. A total of 3,935 questionnaires were mailed to beef producers resulting in 1,211 usable responses, for a response of 30.8 percent. There were 4,516 questionnaires mailed to dairymen, with 1,367 usable responses, for a 30.3 percent response. Information from these questionnaires was useful in identifying differences in management practices and geographic sources of breeding stock purchases and in assessing producer costs associated with several brucellosis-related management practices.

Program Alternatives Modeled

The following brucellosis programs were modeled:

Program Index	Program Alternatives
1	Base Model Year 1975-76

The base model was designed to simulate conditions prevailing in 1975-76 (the year prior to the formation of the Commission and the first year of the Commission's activity). Included in this model are the 1975-76 levels of vaccination, surveillance, levels of infection, levels of management and prevailing Uniform Methods and Rules. Within this model, brucellosis infection was assumed to be essentially stabilized at the 1975-76 level, in aggregate. Each of the other program alternatives was designed to represent a single modification from this base program. In this way, the impact of the particular control practice stressed in the program was measured from a base program which was specifically designed to perpetuate infection at the 1975-76 level.

2 Base Model plus accelerated programs

This model was designed to simulate conditions which might prevail under the APHIS "10-Year Accelerated Eradication Program." During the period of time since 1976 in which this Commission has been conducting its study, the States of Tennessee, Georgia, Alabama and Arkansas have entered into this accelerated program. During the period when, and in those regions where, area testing and first point of concentration (FPC) testing is scheduled to take place, program efficiency (the level of infection detection and elimination) is assumed to increase sharply; hence, the level of infection is materially reduced during this period. However, what happens to program efficiency or quality control after area testing is completed and FPC discontinued is crucial to the final outcome. Two alternatives were modeled. In the first (called accelerated program 1) program quality was assumed to remain at the high level reached during area testing and FPC. In the second program (called accelerated program 2) efficiency was projected to drop back to the level which prevailed in the region prior to area testing.

3 <u>Base model plus calfhood vaccination</u>

This model assumed that incentives will be established for increasing calfhood vaccination in Regions 3, 4, 5, 6, and 7. It is assumed that Regions 1, 2, and 8 are already proceeding to bring the disease under control leading to local eradication within those regions. Included in the program would be a requirement in all regions for vaccinating females sold for breeding purposes shipped across state lines (comparable to California import requirements and the North Dakota law). The model tests this program at three levels of herd vaccination; 90 percent or higher (high), 60-89 percent (medium), and 20-59 percent (low). It is assumed that these levels of vaccination were imposed on the <u>base</u> program (Number 1, above).

4 <u>Base model plus whole herd vaccination</u>

This model was designed for use in ares of high prevalence (Regions 3, 4, and 5); the base program was to apply in all other areas. This program assumed that promising research in progress will demonstrate that adult cattle may be vaccinated successfully with reduced dosages and that distinction can be made between field strain and strain 19 titers. High level herd protection by vaccination could thus be achieved much more rapidly by vaccination whole herds than with calfhood vaccination. Vaccination could occur under two plans: (1) Herds known to be infected and (2) High risk, non-infected herds--that is, there are no reactors revealed by complete herd test at the time of vaccination <u>and</u> the herd has not been under quarantine during the past 6 months (see pages 6-12 through 6-14 of the Commission's report).

<u>Infected herds</u>

For "infected herds," or herds of unknown status at high risk of infection, the entire herd would be tested and reactors would be branded and slaughtered. The test-negative animals 10 months of age and over would be vaccinated with a reduced dose of vaccine (ca 5 x 10^9 cells) subcutaneously and receive the AV brand as in the current guidelines. The herd would remain under quarantine. Testing should be resumed not later than 6 months post vaccination and reactors to the rivanol or

CF at 1:20 would be slaughtered. Quarantine would be lifted after two consecutive negative whole herd tests 6 and 12 months after the first negative herd test. Test-negative would be on the basis of negative rivanol or CF < 1:20. AV branded animals negative on these tests may move or be sold thereafter subject to similar test requirements as applies to all other similar types of cattle.

High risk, noninfected herds (see pages 6-14 and 6-19 of the Commission's report.)

For noninfected qualified herds at high risk, the entire herd must test negative, animals would be vaccinated as above and identified with a new official AV tattoo and individual identification. Animals could be moved or sold on the basis of a negative test 3-6 months after vaccination of test eligible animals (those over 12 months of age).

5 No program

Although highly unlikely that support for brucellosis programs will be cancelled, a "No Program" scenario was developed in order to determine the effects of such a situation upon the economy. "No federal program support" suggests that all surveillance systems would be cancelled and federal support presently existing for laboratory facilities, testing equipment and facilities, field tests, indemnities, financial aid to state programs, etc., would be curtailed. Although many states likely would provide services to protect against the spread of the disease, the scenario assumes no state programs, as well. The physical losses projected for this program option were taken, largely, from the "No Program - No Vaccination" Option of the APHIS, USDA model.

CHAPTER III

BASIC INPUTS FOR ESTIMATING BENEFITS

We identify as benefits from investment in bovine brucellosis control the avoidance or reduction in losses caused by the infection. These losses fall into three categories: (1) economic losses arising from infection of people with Brucella; (2) economic losses generated by management constraints attributable to brucellosis and programs to control or eradicate it; (3) physical reductions in meat and milk due to the disease.

Economic Losses From Human Brucellosis

A full report on the human health dimensions of brucellosis is included as Appendix A of this Commission Report. Included in that report are summaries of different estimates of the direct and indirect medical costs associated with individual cases of human brucellosis. The most current and detailed estimate of the direct medical costs (such as physician, hospital, lab tests, medication, etc.) and indirect costs (such as time lost from work, cost of replacement, workman's compensation, etc.) covering 47 cases at a meat-packing plant in Iowa was $4,617 per case. If this estimate is multiplied by the 282 reported cases in the United States for 1976, the cost of reported human brucellosis would be approximately $1.3 million for the year. But this is not an estimate of the national economic loss due to human brucellosis.

Two overriding problems led the Technical Commission not to attempt an estimate of the economic loss from human brucellosis. First, the actual number of cases is unknown, since the majority of human cases are not diagnosed and are not reported. Although some estimates have been made of the number of unreported cases which might occur for every case which is reported, there is little basis for such estimates and their variance is too great for credibility. Equally important is the difficulty in determining economic losses associated with pain and suffering to patients and to members of the patient's family, relatives and friends, as well as the decreased proficiency of the affected persons as a result of illness. Hence, although the magnitude of total economic losses due to human brucellosis, including compensation for physical and emotional suffering, may be very great, they have not been included in this benefit/cost analysis.

Losses Generated By Livestock Movement Constraints

In the aggregate, the direct physical losses of beef from brucellosis infection during the base years of 1975-76 and during subsequent years had less impact on the total supply and, consequently, on the price of beef than did either the cattle cycle or drouth. That is, the average annual loss from brucellosis per beef herd in the U.S. has been relatively small in recent years. However, these losses have not been equally distributed among all herds.[1] In some instances the impact might be catastrophic to an individual

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[1]From studies in England, for example, Hugh-Jones budgeted differences of £12 in gross profit margins per dairy cow between "clean" herds and herds with a 15% reactor rate, with differences ranging up to £49 between a healthy herd and herds with a 31% reactor rate experiencing a 20% abortion rate. Corresponding profit margin differences in beef herds were £7 and £49, respectively.

producer. They accrue most heavily to those with infected herds or in the high prevalence regions. Thus, those who are in certified free states, or who have certified free herds, have few movement constraints and therefore have increased economic benefits.

An important set of costs associated with this disease, therefore, is associated with individual strategies and collective policies and procedures designed to minimize the likelihood of individual producers suffering such losses. These costs occur in various ways, such as added fencing to restrict cattle movement within the operation, calving pens to achieve isolation during and following calving, and other management practices applying sound epidemiologic techniques. Additionally, constraints have been imposed on movement of cattle infected with or exposed to brucellosis. Moreover, constraints are placed on movements across state lines of cattle from high prevalence states. To the extent these constraints handicap producers in moving cattle to better equate cattle numbers with local feed conditions, they increase costs.

Brucellosis and programs to control or eradicate it may also be disruptive of normal market patterns and channels. Infection tends to spread most rapidly in beef herds during the mid- to late stages of gestation, which is usually a most inopportune time to sell breeding cows for slaughter. However, reactor cattle are removed from the premises and disposed of within 15 days of the date of identification.[2] Moreover, optimum marketing of both beef and dairy animals for breeding or milking purposes requires that each producer have maximum flexibility of animal movement in order to broaden the geographic and time dimensions of his market. However, epidemiologists agree that restrictions on the movement of infected and exposed cattle is essential for effective control of the disease.

Although many of these constraints on cattle movement are specified in the U M and R, eliminating the National Brucellosis Eradication Program might not alter many of the constraints. Conceivably, total management constraints imposed on producers may be less under the present program than might occur if all federal programs were discontinued and the states and individual operators were left to develop their own strategies for coping with disease. Twenty-eight states have already established constraints which are more severe than the U M and R, and other have indicated that their regulations would become more severe if there were no federal program. The point is that constraints on cattle movement are an essential component of strategies to cope with the disease.

As pointed out above, an important economic benefit to be derived from local eradication of brucellosis would be the elimination of restrictions on cattle movement. The magnitude of these benefits would vary greatly depending on individual management, financing and marketing strategies; weather patterns and feed alternatives; the timing in the cattle cycle; and many other factors. After careful consideration, the Technical Commission concluded that although many producers are enjoying the economic benefits associated with free movement

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[2] Infected cattle must be identified with a "B" firebrand on the left jaw and ear-tagged within 15 days of a positive test.

of livestock, considerable additional benefits could be derived from the elimination of constraints on cattle movement through local eradication of brucellosis. However, these benefits could not be quantified with an acceptable degree of precision and therefore were not included in this benefit/cost analysis.

Physical Production Losses

The production losses stem basically from damage to uterine and mammary tissue caused by *Brucella abortus* infection. The component sources of production loss were identified as follows: (1) from dairy and beef calf loss due to abortion, including losses of calves born so weak that they die within seven days; (2) from infection resulting in calves which are born weak but which live. Most of these calves live to perform some economic function but do not compensate for their weight loss by the time they are weaned; (3) from milk losses due to pathologic insult to mammary tissue; (4) from effects of infection on reproductive efficiency; and (5) from loss of genetic potential for production due to increased involuntary culling.

Although brucellosis infection affects beef and dairy cows alike, the relative importance of the component sources of production loss differs significantly between the two. Hence, they are generally treated separately throughout this report. Estimates of physical losses are based upon coefficients prepared by members of the Commission after (1) a review of literature reporting studies of the impacts of brucellosis on physical production of cattle; (2) an extensive sampling and analysis of program data from one or more states in each of the eight regions; (3) information and judgments supplied by regional epidemiologists, state program supervisors and experienced ranchers and dairymen in response to questionnaires, extensive correspondence and numerous telephone calls.

Beef Losses

The component sources of physical production losses for beef cattle, including estimates of the most likely expected occurrence for each source in undetected, infected herds are outlined for unvaccinated herds in Table 1, by year of infection. A discussion of the breakdown of infected herds into undetected and detected herds and the significance of this distinction in the model is presented in Annex 1.

Table 1. Estimated Distribution of Infected Cows by Source of Physical Losses for Unvaccinated, Undetected, Infected Beef Herds, by Year of Infection.

Item	Year of Infection 1	2	3
	- - - Percent of Infected Cows - - -		
Aborters[a]	60	5	0.1
Non-Aborters:	40	95	99.9
Weak Calves	(30)	(6)	(3)
Decreased Milk Production	(25)	(12)	(10)
Slow Breeders	(0)	(15)	(10)
Others	(45)	(67)	(77)

[a]Includes weak calves which die within seven days after birth.

Sixty percent of the cows and bred heifers which become infected are expected to either abort or to have calves which die within seven days of birth during the first year of infection. However, if infected cows are retained in the herd, the likelihood of their aborting the second year of infection drops to 5 percent and becomes negligible (0.1 percent) for the third year.

Of the remaining 40 percent of the undetected infected herd (those which did not abort during the first year of infection), 30 percent (or 12 percent of the total) are likely to produce calves that are weak but which live. An additional 25 percent (10% of the total) are likely to suffer detectable milk production loss. The combination of weak calves and milk loss results in lower weight calves at weaning time.

Once herds have been indentified as infected, the abortion rate drops off sharply because some of the infected cows are identified and shipped to slaughter before they abort. In this study, it was assumed that 50 percent of infected cows were detected and removed from the herd prior to aborting or calving; thus the percentage that would abort, have weak calves, etc. in detected herds were reduced by 50 percent from the data shown in Table 1 for undetected herds.

The impact of the disease on physical losses is influenced by: (1) the rates at which infected cows are culled, (2) the year of infection, and (3) the rate at which replacements are added to infected herds. In undetected herds, the likelihood of culling depends heavily on whether or not the cow aborts. Among cows that abort, the culling rate will vary from region to region due to prevailing management practices. Culling rates are higher where herds are smaller and where they tend to be kept under closer surveillance than in regions where herds are larger and scattered over vast acreages. Table 2 outlines the culling rate used in the simulation model by regions. These data represent the combined judgments of the members of the Technical Commission, augmented by inputs from USDA regional epidemiologists.

Table 2. Producer Culling Rates, Undetected and Infected Herds by Year of Infection, and Region, 1975-76

Item	Region							
	1	2	3	4	5	6	7	8
	- - - - - Percent of Infected Cows - - - - -							
Aborters [a]	80	70	65	65	65	85	85	85
Non-Aborters: [b]								
Year 1	30	30	30	30	30	30	30	30
Year 2	25	25	25	25	25	25	25	25
Year 3	20	20	20	20	20	20	20	20

[a] Culling rates for aborting cows applies to all years of infection.

[b] Non-aborting culling rates are for cows with decreased milk production, slow conception rates, and cows producing weak calves.

The loss category percentages outlined in Table 1 and the culling rates specified in Table 2 were used in calculating the percent of infected cows which were culled from unvaccinated, undetected herds or which fell into selected loss categories.[3] These percentage figures are outlined in Table 3. Similar data for the unvaccinated, detected herds are outlined in Table 4.

Estimates of losses in beef production due to brucellosis depend heavily on the weight assumed for animals lost through abortion and death loss. At one extreme, the loss might be considered equal to average calf weight at birth or when it might be slaughtered as a "vealer". At the other extreme, the loss might be identified as the calf's projected slaughter weight as a U. S. choice slaughter steer of approximately 1100 pounds. The Commission selected 425 pounds to represent the average weaning weight for beef calves. This weight represents the physical loss to the initial or primary stage beef producers. A four percent shrink was then applied to represent the typical selling weight of weaner calves: 425 x (1.0 - .04) = 408 pounds.[4]

Beef losses due to calf deaths were calculated as follows (using as an example, Region 1 and first year of infection):

408 x .6220 x .85 = 215.7 pounds per infected cow, where:

408 = selling weight of weaner calves,

.6220 = the proportion of infected, undetected cows with dead calves in the first year of infection (from Table 3).

.85 = representing a 15 percent adjustment to account for the reduction in maintenance requirements for cows with dead calves, resulting in more available forage for cows nursing calves.

Calf weight losses per infected cow were calculated as follows (again using Region 1 and first year of infection):

408 x .20 x .1980 = 16.2 pounds, where:

.20 = calf weight loss resulting from having been born weak and from decreased milk production of the infected mother cow,

.1980 = the percent of infected cows with calves subject to weight losses (from Table 3).

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[3] The procedures used in calculating data for Table 3 are described in Annex 3.

[4] The assumptions and calculations for converting liveweight weaner calf losses to ultimate carcass weights are outlined in Annex 4.

Table 3. Percent of Infected Cows Culled or Falling into Selected Loss Categories by Year of Infection; Unvaccinated, Undetected Beef Herds.

Item	Year of Infection 1	2	3
	-------Percent of Infected Cows----		
Region 1			
Culled[a]	54.60	44.86	29.60
Have dead calves[b]	62.20	49.60	30.56
Have lower weight calves[c]	19.80	18.80	16.63
Delayed conception or open	-	6.47	7.00
Region 2			
Culled	48.60	39.05	24.41
Have dead calves	62.20	47.94	27.17
Have lower weight calves	19.80	18.67	16.27
Delayed conception or open	-	7.32	7.72
Region 3			
Culled	45.60	36.21	22.03
Have dead calves	62.20	47.11	25.52
Have lower weight calves	19.80	18.60	16.09
Delayed conception or open	-	7.75	8.06
Region 4			
Culled	45.60	36.21	22.03
Have dead calves	62.20	47.11	25.52
Have lower weight calves	19.80	18.60	16.09
Delayed conception or open	-	7.75	8.06
Region 5			
Culled	45.60	36.21	22.03
Have dead calves	62.20	47.11	25.52
Have lower weight calves	19.80	18.60	16.09
Delayed conception or open	-	7.75	8.06
Region 6			
Culled	57.60	47.95	32.53
Have dead calves	62.20	50.44	32.33
Have lower weight calves	19.80	18.87	16.81
Delayed conception or open	-	6.04	6.62
Region 7			
Culled	57.60	47.95	32.53
Have dead calves	62.20	50.44	32.33
Have lower weight calves	19.80	18.87	16.81
Delayed conception or open	-	6.04	6.62

(continued next page)

Table 3. (Continued)

Item	Year of Infection 1	2	3
	-------Percent of Infected Cows-----		
Region 8			
Culled	57.60	47.95	32.53
Have dead calves	62.20	50.44	32.33
Have lower weight calves	19.80	18.87	16.81
Delayed conception or open	-	6.04	6.62

[a]Culled because of abortion and poor performance.

[b]Abortion and early calf death within one week of birth.

[c]Resulting from weak calves and inadequate milk production.

Table 4. Percent of Infected Cows Culled or Falling into Selected Loss Categories by Year of Infection; Unvaccinated, Detected Beef Herds.

Item	Year of Infection 1	2	3
	-------Percent of Infected Cows----		
Culled[a]	100.00	100.00	100.00
Dead calves[b]	31.10	3.36	0.70
Calf weight losses[c]	9.90	7.90	5.84
Delayed conception or open	-	7.12	5.00
Normal weight calves	9.00	31.82	38.46
Identified prior to aborting or calving	50.00	50.00	50.00

[a]Assumes all infected cows are culled from quarantined herds when identified.

[b]Abortion or calf death within one week of birth.

[c]Resulting from weak calves and inadequate milk production.

Table 5. Liveweight Weaner Calf Losses per Infected Beef Cow due to Brucellosis, by Region and Year of Infection for Unvaccinated, Undetected Herds

Region & Item	Year of Infection 1	2	3
	--------Pounds per Infected Cow--------		
Region 1			
Calf deaths	215.7	172.0	106.0
Calf weight losses	16.2	15.3	13.6
Delayed calving	-	6.6	7.1
	231.9	193.9	126.7
Region 2			
Calf deaths	215.7	166.3	94.2
Calf weight losses	16.2	15.2	13.3
Delayed calving	-	7.5	7.9
	231.9	189.0	115.4
Region 3			
Calf deaths	215.7	163.4	88.5
Calf weight losses	16.2	15.2	13.1
Delayed calving	-	7.9	8.2
	231.9	186.5	109.8
Region 4			
Calf deaths	215.7	163.4	88.5
Calf weight losses	16.2	15.2	13.1
Delayed calving	-	7.9	8.2
	231.9	186.5	109.8
Region 5			
Calf deaths	215.7	163.4	88.5
Calf weight losses	16.2	15.2	13.1
Delayed calving	-	7.9	8.2
	231.9	186.5	109.8
Region 6			
Calf deaths	215.7	174.9	112.1
Calf weight losses	16.2	15.4	13.7
Delayed calving	-	6.2	6.8
	231.9	196.5	132.6
Region 7			
Calf deaths	215.7	174.9	112.1
Calf weight losses	16.2	15.4	13.7
Delayed calving	-	6.2	6.8
	231.9	196.5	132.6
Region 8			
Calf deaths	215.7	174.9	112.1
Calf weight losses	16.2	15.4	13.7
Delayed calving	-	6.2	6.8
	231.9	196.5	132.6

Table 6. Liveweight Weaner Calf Losses per Infected Beef Cow due to Brucellosis by Region and Year of Infection for Vaccinated, Undetected Herds[a]

Region & Item	Year of Infection 1	2	3
	--------Pounds per Infected Cow------------		
Region 1			
Calf deaths	193.9	154.6	95.3
Calf weight losses	14.6	13.8	12.2
Delayed calving	-	5.9	6.4
	208.5	174.3	113.9
Region 2			
Calf deaths	193.9	149.5	84.7
Calf weight losses	14.6	13.7	12.0
Delayed calving	-	6.7	7.1
	208.5	169.9	103.8
Region 3			
Calf deaths	193.9	146.9	79.5
Calf weight losses	14.6	13.7	11.8
Delayed calving	-	7.1	7.4
	208.5	167.7	98.7
Region 4			
Calf deaths	193.9	146.9	79.5
Calf weight losses	14.6	13.7	11.8
Delayed calving	-	7.1	7.4
	208.5	167.7	98.7
Region 5			
Calf deaths	193.9	146.9	79.5
Calf weight losses	14.6	13.7	11.8
Delayed calving	-	7.1	7.4
	208.5	167.7	98.7
Region 6			
Calf deaths	193.9	157.3	100.8
Calf weight losses	14.6	13.8	12.3
Delayed calving	-	5.6	6.1
	208.5	176.7	119.2
Region 7			
Calf deaths	193.9	157.3	100.8
Calf weight losses	14.6	13.8	12.3
Delayed calving	-	5.6	6.1
	208.5	176.7	119.2
Region 8			
Calf deaths	193.9	157.3	100.8
Calf weight losses	14.6	13.8	12.3
Delayed calving	-	5.6	6.1
	208.5	176.7	119.2

aThe above weight losses were derived by adjusting calf weight losses from unvaccinated and undetected infected cows by .899.

Decreased calf production per infected cow as a result of delayed conception or open cows was calculated as follows (using Region 1 and second year of infection as an example):

$408 \times .25 \times .0647 = 6.6$ pounds, where:

.25 = three months' delay in calving as a result of slow breeders and/or open cows,

.0647 = percent of infected cows designated as slow breeders or open in Year 2 of infection (from Table 3).

Following the above procedures, the beef losses per infected cow in unvaccinated, undetected herds were estimated for all regions by year of infection, and are listed in Table 5. Differences among regions in beef losses per infected cow is due primarily to differences in management practices manifest by differences in culling rates.

Beef losses per infected cow for vaccinated, undetected herds are shown in Table 6. These losses were estimated by multiplying each of the weight losses in Table 5 by .899, representing a 10.1 percent effectiveness of vaccination in reducing such physical losses as abortion, weak calves, etc., in brucellosis-infected cows. A high level of vaccination has been found to substantially reduce the likelihood of infection. However, it has only limited effectiveness in reducing physical losses should infection occur.

Beef losses per infected cow in unvaccinated, detected herds are outlined by year of infection in Table 7. We assume that infected cows in detected herds are culled when they are identified. Hence, the differences in regional cull rates represented in Table 5 and 6 for undetected herds drop out, leaving only the differences in year of infection. The losses for vaccinated detected herds, shown in Table 8 were derived by multiplying the loss weights in Table 7 by .899 to represent the modest reduction in physical losses per infected cow attributable to vaccination.

Table 7. Liveweight Weaner Calf Losses per Infected Beef Cow due to Brucellosis, by Year of Infection, Unvaccinated, Detected Herds[a].

Item	Year of Infection 1	2	3
	--Pounds per Infected Cow--		
Calf deaths	126.88	13.71	2.86
Calf weight losses and premature marketings	27.47	21.36	16.20
Normal calves marketed prematurely	22.03	77.90	94.15
Delayed calving of open	-	3.63	2.55
Total	176.38	116.00	115.76

[a] Fifty percent of the infected cows were assumed to be identified as infected and culled prior to aborting or calving.

Table 8. Liveweight Weaner Calf Losses per Infected Beef Cow due to Brucellosis, by Year of Infection, Vaccinated and Detected Herds.[a]

Item	Year of Infection 1	2	3
	----Pounds per Infected Cow--		
Calf deaths	114.07	12.33	2.57
Calf weight losses and premature marketings	24.70	19.20	14.56
Normal calves marketed prematurely	19.80	70.03	84.64
Delayed calvings or open	-	3.26	2.29
Total	158.57	104.82	104.06

[a] Fifty percent of the infected cows were assumed to be identified as infected prior to aborting or calving. The above weight losses were derived by adjusting calf weight losses from zero vaccinated, detected infected cow by .899.

Dairy Losses

The component sources of production losses for dairymen include both milk and beef. Beef losses are attributed to loss of calves through abortion and through weight loss due to weak calves. We assume the same percentage loss of calves from abortion and weak calves for dairy as were used for beef. Table 9 lists the percent of infected cows which abort or produce weak calves for unvaccinated, undetected dairy herds. The percentage distribution for unvaccinated, detected herds was also estimated from Table 9 assuming that half of the infected cows would be detected before they calved or aborted. This modification was accomplished by multiplying the figures for loss categories in Table 9 by .50.

Table 9. Estimated Basic Coefficients Used in Estimating Physical Losses for Unvaccinated, Undetected, Infected Dairy Herds, by Year of Infection.

Item	Year of Infection 1	2	3
	--------Percent of Infected Cows-----		
Aborters[a]	60.0	5.0	0.1
Non-aborters	40.0	95.0	99.9
Weak calves	(30.0)	(6.0)	(3.0)
Others	(70.0)	(94.0)	(97.0)

[a] Includes weak calves which die within seven days after birth

It was assumed that 75 percent of the cows which abort would be culled from undetected herds as milk production dropped off toward the end of their lactation. Additionally, a standard culling rate for dairy cows of .281 was applied each year to cows which show no evidence of infection, for a combined total culling rate of .5624 for unvaccinated, undetected herds during the first year of infection. These culling rates are shown in Table 10 by year of infection, along with the percentage of cows which either abort or have calves which die.[5] Comparable

Table 10. Percent of Brucellosis Infected Dairy Cows Culled and Producing Dead Calves by Year of Infection for Unvaccinated and Undetected Herds.

Item	Year of Infection 1	2	3
	- - - Percent of Infected Cows - - -		
Culled	56.24	50.60	43.15
Have dead calves	61.20	49.03	32.93

data for unvaccinated, detected herds are shown in Table 11. Because detected herds are in quarantine, all infected cows must be culled when identified. Moreover, since half of the infected cows were assumed to be detected prior to aborting or calving, the percentage producing calves which die is one-half that of the undetected herds.

Table 11. Percent of Brucellosis Infected Dairy Cows Culled and Producing Dead Calves, by Year of Infection for Unvaccinated and Detected Herds.

Item	Year of Infection 1	2	3
	---- Percent of Infected Cows ---		
Culled	100.00	100.00	100.00
Have dead calves	30.60	24.52	16.47

Direct milk losses due to brucellosis infection results from damage to mammary tissue and from temporary vacancies in the milking herd due to unplanned culling of infected cows. Estimates of these losses are listed in Table 12 by year of infection for herds of different status. The appropriate figure from Table 12 was multiplied by the average regional milk production per cow shown in Table 13 to get the average milk loss per infected cow for each herd status. For example, the loss per infected cow for unvaccinated, undetected herds in Region 1 would be 10,699 x .095 = 1016.4 lbs.

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[5] The detailed procedures for calculating the data for Table 10 are described in Annex 5.

Table 12. Percent of Milk Loss per Infected Cow due to Brucellosis by Year of Infection and by Herd Status.

Herd Status and Kind of Milk Loss	Year of Infection 1	2	3
	-- Percent of Milk Loss ---		
unvaccinated, undetected [a]	9.50	10.26	10.50
vaccinated, undetected [b]	8.54	9.22	9.44
unvaccinated, detected [c]	14.00	14.45	14.72
vaccinated, detected [d]	12.58	13.23	13.23

[a] Cows are assumed to be culled at or near the end of lactation. In addition, it is assumed that one-third of the aborters culled represents a one-month lag in obtaining replacement.

[b] Equal to .899 of the preceding row to account for vaccination.

[c] Assumes infection is detected mid-way through lactation, that culling is immediate on detection and that one month lag occurs in obtaining replacements.

[d] Equal to .899 of the preceding row to account for vaccination.

Table 13. Average Regional Milk Production per Cow. 1975-76.

Region	Average Production per Cow in lbs.
1	10,699
2	10,291
3	8,508
4	10,000
5	9,025
6	9,479
7	11,789
8	13,935

Table 14. Milk Losses per Infected Dairy Cow due to Brucellosis, in Unvaccinated, Undetected Herds.

Region & Item	Year of Infection 1	2	3
	---------Pounds per Infected Cow-------------		
Region 1			
Milk loss			
Direct	1,016.4	1,097.7	1,123.4
Genetic	481.4	433.1	396.3
Total	1,497.8	1,530.8	1,519.7
Region 2			
Milk loss			
Direct	977.6	1,055.9	1,080.6
Genetic	463.0	416.6	355.2
Total	1,440.6	1,472.5	1,435.8
Region 3			
Milk loss			
Direct	808.3	872.9	893.3
Genetic	382.8	344.4	293.7
Total	1,191.1	1,217.3	1,187.0
Region 4			
Milk loss			
Direct	950.0	1,026.0	1,050.0
Genetic	449.9	404.8	345.2
Total	1,399.9	1,430.8	1,395.2
Region 5			
Milk loss			
Direct	857.4	926.0	947.6
Genetic	406.1	365.3	311.5
Total	1,263.5	1,291.3	1,259.1
Region 6			
Milk loss			
Direct	900.5	972.5	995.3
Genetic	426.5	383.7	327.2
Total	1,327.0	1,356.2	1,322.5
Region 7			
Milk loss			
Direct	1,120.0	1,209.6	1,237.8
Genetic	530.4	477.2	407.0
Total	1,650.4	1,686.8	1,644.8
Region 8			
Milk loss			
Direct	1,323.8	1,429.7	1,463.2
Genetic	627.0	564.1	481.0
Total	1,950.8	1,993.8	1,944.2

Table 15. Milk Losses per Infected Dairy Cow due to Brucellosis in Vaccinated, Undetected Herds.

Region & Item	Year of Infection 1	2	3
	---------Pounds per Infected Cow---------		
Region 1			
Milk loss			
Direct	913.7	986.8	1,009.9
Genetic	432.8	389.4	332.0
Total	1,346.5	1,376.2	1,341.9
Region 2			
Milk loss			
Direct	878.9	949.2	971.5
Genetic	416.2	374.5	319.3
Total	1,295.1	1,323.7	1,290.7
Region 3			
Milk loss			
Direct	726.6	784.8	803.1
Genetic	344.1	309.6	264.0
Total	1,070.7	1,094.4	1,067.1
Region 4			
Milk loss			
Direct	854.1	922.4	944.0
Genetic	404.5	363.9	310.3
Total	1,258.6	1,286.3	1,254.3
Region 5			
Milk loss			
Direct	770.8	822.4	851.9
Genetic	365.1	328.4	280.0
Total	1,135.9	1,150.8	1,131.9
Region 6			
Milk loss			
Direct	809.6	874.3	894.8
Genetic	383.4	345.0	294.2
Total	1,193.0	1,219.3	1,189.0
Region 7			
Milk loss			
Direct	1,007.0	1,087.4	1,112.8
Genetic	476.8	429.0	365.9
Total	1,483.8	1,516.4	1,478.7
Region 8			
Milk loss			
Direct	1,190.1	1,285.3	1,315.4
Genetic	563.7	507.1	432.4
Total	1,753.8	1,792.4	1,747.8

Table 16. Milk Losses per Infected Diary Cow due to Brucellosis in Vaccinated, Detected Herds.

Region & Item	Year of Infection 1	2	3
	---------Pounds per Infected Cow-------------		
Region 1			
Milk loss			
Direct	1,346.6	1,389.8	1,415.8
Genetic	769.5	769.5	769.5
Total	2,176.1	2,159.3	2,185.3
Region 2			
Milk loss			
Direct	1,295.1	1,336.8	1,361.8
Genetic	740.2	740.2	740.2
Total	2,035.3	2,077.0	2,102.0
Region 3			
Milk loss			
Direct	1,070.8	1,105.2	1,125.9
Genetic	611.9	611.9	611.9
Total	1,682.7	1,717.1	1,737.8
Region 4			
Milk loss			
Direct	1,258.6	1,299.1	1,323.3
Genetic	719.2	719.2	719.2
Total	1,977.8	2,018.3	2,042.5
Region 5			
Milk loss			
Direct	1,135.9	1,172.4	1,194.3
Genetic	649.1	649.1	649.1
Total	1,785.0	1,821.5	1,843.4
Region 6			
Milk loss			
Direct	1,193.1	1,231.4	1,254.4
Genetic	681.7	681.7	681.7
Total	1,874.8	1,913.1	1,936.1
Region 7			
Milk loss			
Direct	1,483.8	1,531.4	1,560.0
Genetic	847.9	847.9	847.9
Total	2,331.7	2,379.3	2,407.9
Region 8			
Milk loss			
Direct	1,753.9	1,810.2	1,844.0
Genetic	1,002.2	1,002.2	1,002.2
Total	2,756.1	2,812.4	2,846.2

Table 17. Milk Losses per Infected Diary Cow due to Brucellosis in Unvaccinated, Detected Herds.

Region & Item	Year of Infection 1	2	3
	---------Pounds per Infected Cow-------------		
Region 1			
Milk loss			
Direct	1,497.9	1,546.0	1,574.9
Genetic	855.9	855.9	855.9
Total	2,353.8	2,401.9	2,430.8
Region 2			
Milk loss			
Direct	1,440.7	1,487.0	1,514.8
Genetic	823.3	823.3	823.3
Total	2,264.0	2,310.3	2,338.1
Region 3			
Milk loss			
Direct	1,191.1	1,229.4	1,252.4
Genetic	680.6	680.6	680.6
Total	1,871.7	1,910.0	1,933.0
Region 4			
Milk loss			
Direct	1,400.0	1,445.0	1,472.0
Genetic	800.0	800.0	800.0
Total	2,200.0	2,245.0	2,272.0
Region 5			
Milk loss			
Direct	1,263.5	1,304.1	1,328.5
Genetic	722.0	722.0	722.0
Total	1,985.5	2,026.1	2,050.5
Region 6			
Milk loss			
Direct	1,327.1	1,369.7	1,395.3
Genetic	758.3	758.3	758.3
Total	2,085.4	2.128.0	2,153.6
Region 7			
Milk loss			
Direct	1,650.5	1,703.5	1,735.3
Genetic	943.1	943.1	943.1
Total	2,593.6	2,646.6	2,678.4
Region 8			
Milk loss			
Direct	1,950.9	2,013.6	2,051.2
Genetic	1,114.8	1,114.8	1,114.8
Total	3,065.7	3,128.4	3.166.0

Indirect milk loss due to brucellosis may be due to a lowering of the genetic base due to forced culling. This loss is estimated at 8 percent[6] for each infected cow culled. It is estimated as: .08 x Regional production per cow x relevant culling coefficient from Tables 10 and 11.

The combined milk losses due to infected cows and loss of genetic base are listed by regions and by year of infection in: Table 14 for unvaccinated, undetected herds; Table 15 for vaccinated, undetected herds; Table 16 for unvaccinated detected herds; and Table 17 for vaccinated, detected herds.

Practices differ among dairymen for disposing of bull and surplus dairy heifer calves. The predominent practice, however, among commercial dairymen is to dispose of surplus calves by selling them to others who then either prepare them for slaughter as vealers or grow them out as stockers and feeders or as dairy replacements in other areas. To simplify the analysis, we assume that all surplus dairy calves are sold within a few days of birth at an average weight of 85 lbs. The estimated live weight calf loss due to brucellosis is shown in Table 18 by herd status and by year of infection.

Table 18. Liveweight Calf Loss due to Brucellosis by Herd Status and by Year of Infection, per Infected Dairy Cow

Herd Status	Year of Infection 1	2	3
	- - - - Pounds, Liveweight- - - -		
Unvaccinated, undetected[a]	52.0	41.7	28.0
Vaccinated, undetected[b]	46.7	37.5	25.2
Unvaccinated, detected[c]	36.0	20.8	14.0
Vaccinated, detected[d]	23.4	18.7	12.6

[a]Equal to 85 lbs. times the appropriate coefficient in Table 10.

[b]Equal to .899 of preceding row to account for vaccination.

[c]Equal to 85 lbs. times the appropriate coefficient in Table 11.

[d]Equal to .899 of preceding row to account for vaccination.

[6]For a defense of this 8 percent assumption, see Annex 6.

CHAPTER IV: ESTIMATES OF ECONOMIC BENEFITS

In this chapter we summarize the projected economic benefits to be derived from alternative brucellosis programs. As stated in Chapter III, benefits are defined in terms of reduced losses due to brucellosis resulting from alternative programs to control or eradicate the disease. We will first summarize the physical losses of meat and milk associated with each of the five program alternatives tested, by regions and for the U.S. Then, for illustration only, we will estimate the economic losses experienced in 1976 by primary producers (cow-calf operators and dairymen) whose herds were infected with brucellosis, using a partial bud get analysis. Finally, we will assess the economic losses to the total economy resulting from the disease under the five program alternatives.

Physical Production Losses for Alternative Programs

The brucellosis simulation model for the beef and dairy herds was used to project total numbers of infected herds (both undetected and quarantined) as well as the number of infected cows by herd size and by regions for each program alternative. By feeding into the computer model the physical loss coefficients per infected cow outlined in Chapter III (in Tables 5 through 8 for beef and 14 through 18 for dairy), we obtained estimates of the annual regional and U.S. losses for meat and milk for each program alternative.

1. The Base Program

The base program was designed to represent the state-federal brucellosis program in effect during 1975-76. It was assumed that such a program would tend to perpetuate the level of infection at about the level prevailing during those base years. Projections of (1) numbers of infected herds (both undetected and quarantined), (2) numbers of infected cows, and (3) pounds of beef losses (in terms of liveweight weaner calves) due to brucellosis are shown in Table 19-B (beef) by years for the U.S. and for each of the eight regions.

The cryptic column headings of this and subsequent tables require a brief definition. Column 2, "Undetected Infected Herds," lists the number of undetected infected herds in the U.S. or region; Column 3, "Quarantined Herds," shows the projected number of herds under quarantine; Column 4, "Quarantined Infected Cows," lists the projected number of infected cows within the quarantined herds identified in Column 3; while Column 5 , "Infected Cows" lists the number of infected cows within the undetected herds listed in Column 2. The remaining column (columns for the dairy models) identifies the projected physical losses for that specified geographic region and program option. Each value is by year and the values are not cumulative.

Notice that each of these crucial variables fluctuates above and below the level in year 0 (1976) due to, and following closely the pattern of, the cattle cycle. The cull rates built into the beef model reflect a cyclical pattern based on the last two cattle cycles. Total annual beef losses ranged from a low of 64.2 million pounds to a high of 92.0 million pounds, with total accumulated losses over the 20-year period projected to exceed 1.5 billion pounds.

TABLE 19-B.

**************** NBTC SIMULATION MODEL ****************

...... BEEF MODEL .... BASE PROGRAM ....

**************** U. S. T O T A L S*********************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	20465.	15014.	452329.	111862.	80253744.
1	19997.	15824.	353119.	100511.	65357504.
2	20106.	14909.	337725.	101898.	64184336.
3	20194.	14922.	351992.	105049.	66648624.
4	21821.	13669.	340106.	115279.	67036016.
5	22265.	15405.	387410.	119329.	74082800.
6	24067.	14986.	383609.	129591.	75523392.
7	25740.	15963.	415485.	139629.	81768752.
8	24183.	20461.	504058.	131680.	91960480.
9	22453.	21211.	497218.	120074.	88958384.
10	22955.	18043.	427557.	121000.	79883664.
11	23327.	17459.	423683.	123408.	79755088.
12	23292.	17920.	434838.	123281.	81183888.
13	21708.	19564.	459991.	114532.	82941136.
14	22138.	17076.	403915.	115851.	75663568.
15	22076.	17067.	410018.	116115.	76592768.
16	21182.	17901.	422649.	112030.	77397760.
17	20703.	17246.	405057.	109001.	74438720.
18	18553.	18438.	421858.	97630.	74791088.
19	18197.	15762.	362438.	95608.	66374400.

**************** R E G I O N 1 T O T A L S************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	148.	150.	2593.	570.	457179.
1	150.	150.	2022.	565.	383536.
2	146.	146.	2027.	562.	385171.
3	145.	141.	2072.	570.	392217.
4	158.	126.	1926.	631.	384214.
5	165.	142.	2233.	663.	432219.
6	183.	139.	2205.	741.	443575.
7	201.	151.	2468.	820.	494574.
8	186.	201.	3189.	750.	579378.
9	160.	207.	3093.	638.	545636.
10	160.	166.	2436.	634.	455265.
11	163.	155.	2354.	648.	446374.
12	158.	164.	2494.	628.	461247.
13	143.	174.	2579.	563.	461027.
14	142.	149.	2195.	560.	407903.
15	141.	146.	2185.	556.	405870.
16	134.	150.	2243.	530.	408901.
17	130.	143.	2118.	516.	389326.
18	102.	163.	2387.	393.	401028.
19	102.	120.	1646.	393.	301742.

TABLE 19-B (Continued).

***************** NBTC SIMULATION MODEL *****************

•••••• BEEF MODEL ••••••••• BASE PROGRAM ••••••••

**************** R E G I O N 2 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	38.	27.	324.	97.	61575.
1	43.	37.	430.	122.	81732.
2	45.	42.	540.	136.	99481.
3	48.	45.	594.	148.	109226.
4	55.	43.	587.	177.	113897.
5	60.	51.	730.	194.	136593.
6	70.	52.	744.	228.	145056.
7	79.	59.	864.	261.	167819.
8	76.	80.	1150.	239.	201930.
9	69.	83.	1090.	212.	188662.
10	70.	70.	904.	215.	163779.
11	74.	65.	876.	229.	162570.
12	73.	71.	960.	226.	173351.
13	69.	76.	995.	210.	175150.
14	69.	68.	882.	212.	160137.
15	69.	68.	900.	211.	162251.
16	67.	70.	916.	203.	162795.
17	66.	67.	875.	199.	156605.
18	56.	75.	951.	167.	161002.
19	55.	60.	748.	166.	133434.

**************** R E G I O N 3 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	5092.	3462.	79878.	20316.	14331217.
1	5109.	3916.	63779.	19535.	12083454.
2	5184.	3925.	63069.	20005.	12132590.
3	5287.	3952.	65528.	20790.	12577179.
4	5918.	3530.	60019.	24156.	12519389.
5	6194.	4033.	73155.	25734.	14570018.
6	6804.	4060.	73937.	28621.	15207318.
7	7399.	4389.	81807.	31409.	16797520.
8	7059.	5749.	104941.	29299.	19469152.
9	6686.	6105.	103187.	26957.	18799600.
10	6780.	5474.	90344.	26971.	17090576.
11	6925.	5222.	87912.	27680.	16843152.
12	6922.	5356.	91503.	27421.	17284832.
13	6657.	5647.	94143.	26109.	17411152.
14	6719.	5229.	85708.	26342.	16318993.
15	6701.	5195.	86939.	26287.	16467481.
16	6576.	5288.	87955.	25740.	16508191.
17	6511.	5172.	85149.	25517.	16091781.
18	5904.	5625.	91312.	22958.	16482777.
19	5810.	4929.	78574.	22470.	14671780.

TABLE 19-B (Continued).

**************** NBTC SIMULATION MODEL *****************

...... BEEF MODEL .... BASE PROGRAM ....

*************** R E G I O N 4 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	1149.	587.	31204.	8718.	5658272.
1	1133.	609.	24849.	7727.	4649237.
2	1125.	602.	24655.	7727.	4680253.
3	1130.	593.	26120.	8063.	4932771.
4	1178.	561.	26697.	8598.	5102817.
5	1203.	602.	28963.	8959.	5470411.
6	1267.	590.	29597.	9535.	5655894.
7	1330.	619.	31493.	10104.	6011458.
8	1304.	743.	35262.	10048.	6507061.
9	1251.	791.	36010.	9738.	6554321.
10	1266.	714.	34108.	9796.	6312566.
11	1296.	689.	33807.	10000.	6309293.
12	1297.	724.	34885.	10040.	6458327.
13	1258.	772.	35832.	9807.	6544263.
14	1271.	716.	34354.	9853.	6354662.
15	1274.	718.	34504.	9870.	6378774.
16	1258.	738.	34906.	9774.	6414847.
17	1253.	725.	34463.	9728.	6347627.
18	1165.	804.	35696.	9213.	6424972.
19	1159.	705.	33117.	9101.	6059300.

*************** R E G I O N 5 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	12872.	9396.	299015.	76189.	53320768.
1	12460.	9539.	234687.	67333.	43430528.
2	12584.	8675.	219963.	68379.	42141136.
3	12615.	8696.	229403.	70481.	43798624.
4	13464.	8039.	224282.	76153.	44173312.
5	13622.	9048.	250779.	78245.	48068784.
6	14623.	8657.	247180.	84333.	48752432.
7	15525.	9171.	265592.	90314.	52400544.
8	14517.	11729.	318928.	85447.	58497936.
9	13378.	12075.	316734.	77414.	56794272.
10	13751.	9967.	268446.	78239.	50556192.
11	13934.	9749.	267444.	79646.	50679584.
12	13912.	10009.	273376.	79768.	51448416.
13	12759.	11196.	293317.	73180.	52898608.
14	13093.	9407.	251871.	74153.	47526928.
15	13047.	9461.	256179.	74439.	48221888.
16	12376.	10101.	266226.	71404.	48880080.
17	12008.	9655.	253998.	68893.	46742528.
18	10704.	10273.	262883.	61362.	46707776.
19	10464.	8643.	224396.	60040.	41248240.

TABLE 19-B (Continued).

**************** NBTC SIMULATION MODEL ****************

...... BEEF MODEL .... BASE PROGRAM ....

**************** R E G I O N 6 T O T A L S************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	735.	1050.	27961.	4003.	4527851.
1	721.	1149.	19842.	3643.	3416040.
2	682.	1124.	20303.	3602.	3490787.
3	658.	1124.	21042.	3566.	3584538.
4	741.	1033.	19648.	4107.	3517845.
5	729.	1181.	23986.	4099.	4099542.
6	825.	1152.	22618.	4637.	4031969.
7	906.	1231.	25411.	5156.	4522689.
8	766.	1568.	31740.	4417.	5213348.
9	668.	1543.	28493.	3806.	4651509.
10	695.	1293.	23966.	3892.	4060682.
11	705.	1248.	24128.	3960.	4095463.
12	707.	1265.	24388.	3980.	4134982.
13	614.	1365.	25906.	3499.	4240178.
14	642.	1191.	22091.	3601.	3746074.
15	646.	1174.	22652.	3644.	3832264.
16	580.	1249.	23771.	3303.	3908024.
17	550.	1187.	22003.	3103.	3627153.
18	467.	1189.	22030.	2640.	3540265.
19	453.	1036.	18524.	2568.	3049454.

**************** R E G I O N 7 T O T A L S************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	407.	323.	10910.	1900.	1823039.
1	358.	400.	7100.	1510.	1242884.
2	319.	369.	6676.	1410.	1172652.
3	290.	344.	6700.	1352.	1165994.
4	285.	312.	6418.	1371.	1134929.
5	269.	320.	6961.	1347.	1205018.
6	272.	309.	6731.	1396.	1185901.
7	275.	313.	7194.	1460.	1263711.
8	252.	355.	8083.	1387.	1369130.
9	221.	371.	7904.	1230.	1312607.
10	213.	329.	6769.	1175.	1149329.
11	210.	303.	6588.	1164.	1123784.
12	202.	301.	6626.	1138.	1124061.
13	190.	305.	6607.	1092.	1112999.
14	184.	288.	6276.	1057.	1061045.
15	180.	277.	6115.	1036.	1035465.
16	173.	276.	6081.	1008.	1025749.
17	167.	270.	5927.	977.	998661.
18	140.	282.	6056.	842.	988237.
19	139.	245.	4991.	815.	839376.

TABLE 19-B (Continued).

**************** NBTC SIMULATION MODEL *****************

...... BEEF MODEL .... BASE PROGRAM ....

**************** R E G I O N 8 T O T A L S************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	24.	20.	446.	69.	73887.
1	23.	25.	409.	74.	70118.
2	22.	27.	493.	78.	82300.
3	21.	27.	532.	79.	88107.
4	22.	26.	529.	88.	89640.
5	23.	29.	604.	90.	100246.
6	24.	29.	599.	98.	101279.
7	26.	30.	655.	106.	110467.
8	23.	36.	764.	93.	122582.
9	20.	37.	706.	78.	111819.
10	20.	31.	584.	79.	95301.
11	21.	29.	575.	82.	94897.
12	21.	30.	607.	80.	98719.
13	19.	31.	613.	72.	97783.
14	19.	28.	538.	72.	87856.
15	19.	27.	545.	72.	88810.
16	18.	28.	553.	69.	89225.
17	18.	27.	525.	67.	85060.
18	15.	29.	543.	56.	85083.
19	15.	24.	441.	55.	71112.

TABLE 19-D.

**************** NBTC SIMULATION MODEL ****************

...... DAIRY MODEL .... BASE PROGRAM ....

**************** U. S. T O T A L S**********************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	209.	835.	16800.	1400.	403522.	38057984.
1	165.	815.	15423.	1285.	363686.	35278160.
2	153.	773.	12622.	1052.	299638.	28752864.
3	147.	732.	11717.	976.	278686.	26774128.
4	145.	717.	11362.	947.	270380.	26029184.
5	149.	729.	11330.	944.	269859.	25959904.
6	154.	750.	11533.	961.	274808.	26426608.
7	162.	784.	11925.	994.	284282.	27309504.
8	172.	830.	12483.	1040.	297693.	28546464.
9	174.	846.	12877.	1073.	306969.	29426528.
10	168.	827.	12904.	1075.	307309.	29499184.
11	165.	813.	12798.	1067.	304686.	29276512.
12	166.	812.	12753.	1063.	303665.	29182816.
13	166.	812.	12754.	1063.	303715.	29189248.
14	161.	794.	12624.	1052.	300492.	28907280.
15	159.	781.	12467.	1039.	296719.	28565712.
16	158.	775.	12353.	1029.	294055.	28317168.
17	155.	763.	12215.	1018.	290735.	28015616.
18	151.	747.	12035.	1003.	286388.	27621856.
19	143.	710.	11661.	972.	277331.	26804224.

**************** R E G I O N 1 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	26.	103.	1605.	134.	38659.	4047638.
1	18.	86.	1288.	107.	30618.	3246943.
2	15.	72.	1043.	87.	24903.	2630215.
3	14.	64.	911.	76.	21773.	2296362.
4	13.	59.	830.	69.	19857.	2092023.
5	13.	58.	797.	66.	19091.	2008449.
6	13.	59.	794.	66.	19052.	2002349.
7	14.	62.	820.	68.	19688.	2067428.
8	15.	66.	869.	72.	20871.	2190213.
9	15.	68.	897.	75.	21542.	2262075.
10	14.	65.	883.	74.	21165.	2225533.
11	14.	63.	857.	71.	20554.	2162022.
12	13.	62.	843.	70.	20218.	2125792.
13	13.	62.	833.	69.	19987.	2101242.
14	13.	59.	810.	67.	19415.	2042146.
15	12.	58.	787.	66.	18859.	1983712.
16	12.	56.	770.	64.	18455.	1940806.
17	12.	55.	752.	63.	18036.	1896784.
18	12.	54.	734.	61.	17596.	1850706.
19	11.	50.	692.	58.	16582.	1745666.

TABLE 19-D (Continued).

**************** NBTC SIMULATION MODEL ****************

...... DAIRY MODEL .... BASE PROGRAM ....

*************** R E G I O N 2 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	2.	10.	61.	5.	1474.	147641.
1	1.	6.	58.	5.	1393.	141481.
2	1.	5.	53.	4.	1273.	129709.
3	1.	5.	49.	4.	1161.	118219.
4	1.	5.	46.	4.	1088.	110643.
5	1.	5.	45.	4.	1072.	108789.
6	1.	5.	46.	4.	1095.	111030.
7	1.	6.	48.	4.	1160.	117511.
8	1.	6.	53.	4.	1259.	127433.
9	1.	6.	55.	5.	1327.	134390.
10	1.	6.	56.	5.	1337.	135624.
11	1.	6.	56.	5.	1335.	135406.
12	1.	6.	56.	5.	1344.	136363.
13	1.	6.	57.	5.	1354.	137372.
14	1.	6.	56.	5.	1339.	135864.
15	1.	6.	55.	5.	1324.	134329.
16	1.	6.	55.	5.	1312.	133106.
17	1.	6.	54.	5.	1294.	131329.
18	1.	6.	53.	4.	1274.	129265.
19	1.	5.	51.	4.	1214.	123318.

*************** R E G I O N 3 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	79.	314.	5207.	434.	125173.	10443844.
1	46.	240.	3957.	330.	93406.	7933941.
2	38.	192.	2978.	248.	70720.	5971107.
3	35.	173.	2593.	216.	61763.	5197755.
4	34.	165.	2408.	201.	57435.	4827668.
5	35.	167.	2357.	196.	56314.	4725728.
6	36.	173.	2396.	200.	57301.	4803638.
7	38.	184.	2499.	208.	59804.	5010297.
8	41.	197.	2652.	221.	63498.	5317201.
9	42.	204.	2768.	231.	66248.	5550166.
10	42.	202.	2797.	233.	66875.	5608164.
11	42.	201.	2791.	233.	66699.	5595148.
12	42.	201.	2795.	233.	66805.	5603050.
13	42.	202.	2804.	234.	67030.	5621606.
14	41.	200.	2786.	232.	66585.	5586012.
15	41.	198.	2763.	230.	66028.	5539588.
16	41.	197.	2746.	229.	65618.	5504649.
17	40.	195.	2723.	227.	65060.	5458332.
18	40.	193.	2694.	225.	64381.	5401644.
19	38.	185.	2617.	218.	62504.	5247053.

TABLE 19-D (Continued).

****************** NBTC SIMULATION MODEL ******************

•••••• DAIRY MODEL ••••••••• BASE PROGRAM ••••••••

**************** R E G I O N 4 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	19.	77.	5341.	445.	127983.	12591584.
1	10.	71.	4966.	414.	115681.	11701157.
2	7.	71.	3203.	267.	74809.	7545854.
3	6.	53.	2375.	198.	55856.	5597335.
4	6.	47.	2057.	171.	48507.	4847967.
5	6.	44.	1918.	160.	45312.	4520338.
6	6.	43.	1875.	156.	44345.	4418599.
7	6.	44.	1891.	158.	44743.	4455090.
8	6.	45.	1944.	162.	46042.	4582007.
9	7.	47.	2004.	167.	47449.	4722637.
10	6.	47.	2034.	170.	48135.	4794216.
11	6.	47.	2038.	170.	48212.	4803413.
12	6.	47.	2041.	170.	48294.	4810596.
13	7.	47.	2052.	171.	48550.	4835644.
14	6.	47.	2054.	171.	48577.	4839485.
15	6.	47.	2046.	171.	48390.	4821504.
16	6.	47.	2038.	170.	48212.	4803326.
17	6.	47.	2031.	169.	48043.	4786621.
18	6.	47.	2021.	168.	47800.	4762740.
19	6.	46.	1990.	166.	47042.	4689027.

**************** R E G I O N 5 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	51.	205.	2840.	237.	68287.	6042082.
1	64.	292.	3277.	273.	78322.	6968174.
2	67.	317.	3672.	306.	88069.	7809532.
3	68.	326.	4023.	335.	96192.	8555940.
4	69.	333.	4210.	351.	100587.	8954785.
5	72.	345.	4382.	365.	104683.	9320232.
6	74.	357.	4548.	379.	108628.	9672114.
7	78.	373.	4738.	395.	113179.	10076331.
8	82.	394.	4971.	414.	118764.	10571154.
9	83.	400.	5122.	427.	122310.	10892830.
10	80.	389.	5107.	426.	121838.	10862394.
11	78.	381.	5041.	420.	120223.	10721344.
12	78.	380.	5007.	417.	119447.	10648987.
13	78.	381.	4997.	416.	119228.	10628183.
14	76.	371.	4923.	410.	117393.	10469220.
15	75.	364.	4835.	403.	115296.	10283364.
16	74.	361.	4774.	398.	113856.	10152594.
17	73.	354.	4700.	392.	112078.	9995182.
18	71.	344.	4598.	383.	109634.	9779412.
19	66.	325.	4415.	368.	105202.	9389602.

TABLE 19-D (Continued).

**************** NBTC SIMULATION MODEL ****************

...... DAIRY MODEL .... BASE PROGRAM ....

**************** R E G I O N 6 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	14.	55.	524.	44.	12625.	1170281.
1	15.	69.	573.	48.	13766.	1278924.
2	15.	69.	610.	51.	14682.	1362526.
3	14.	67.	613.	51.	14703.	1368403.
4	14.	65.	596.	50.	14291.	1330592.
5	14.	67.	595.	50.	14296.	1330000.
6	14.	68.	603.	50.	14491.	1347525.
7	15.	72.	627.	52.	15075.	1400991.
8	17.	77.	666.	55.	16014.	1487428.
9	16.	77.	680.	57.	16349.	1519971.
10	15.	73.	663.	55.	15912.	1481259.
11	15.	71.	644.	54.	15444.	1437839.
12	15.	70.	634.	53.	15218.	1416212.
13	15.	70.	631.	53.	15145.	1409048.
14	14.	68.	615.	51.	14745.	1372624.
15	14.	66.	600.	50.	14404.	1340905.
16	14.	65.	592.	49.	14220.	1323308.
17	13.	64.	579.	48.	13899.	1293740.
18	13.	61.	561.	47.	13456.	1252928.
19	12.	57.	530.	44.	12704.	1183617.

**************** R E G I O N 7 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	14.	54.	791.	66.	18977.	2197087.
1	6.	30.	541.	45.	12702.	1504141.
2	4.	21.	368.	31.	8697.	1022447.
3	3.	16.	298.	25.	7055.	828245.
4	3.	14.	250.	21.	5915.	693843.
5	3.	13.	218.	18.	5182.	606896.
6	3.	12.	198.	17.	4712.	551163.
7	3.	12.	186.	16.	4433.	518013.
8	3.	12.	181.	15.	4297.	501599.
9	2.	11.	176.	15.	4177.	487570.
10	2.	11.	168.	14.	3993.	466413.
11	2.	10.	160.	13.	3805.	444590.
12	2.	10.	154.	13.	3656.	426964.
13	2.	9.	149.	12.	3535.	412846.
14	2.	9.	143.	12.	3409.	398190.
15	2.	9.	138.	12.	3292.	384502.
16	2.	8.	134.	11.	3193.	372825.
17	2.	8.	130.	11.	3100.	362046.
18	2.	8.	127.	11.	3010.	351499.
19	2.	7.	120.	10.	2860.	334285.

TABLE 19-D (Continued).

**************** NBTC SIMULATION MODEL ****************

•••••• DAIRY MCDEL ••••••••• BASE PROGRAM ••••••••

**************** R E G I O N 8 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	4.	17.	432.	36.	10343.	1417862.
1	5.	21.	763.	64.	17799.	2503442.
2	6.	26.	695.	58.	16485.	2281511.
3	6.	27.	856.	71.	20184.	2811895.
4	6.	29.	966.	81.	22701.	3171693.
5	6.	30.	1017.	85.	23908.	3339512.
6	7.	31.	1072.	89.	25185.	3520219.
7	7.	32.	1116.	93.	26200.	3663885.
8	7.	33.	1148.	96.	26949.	3769457.
9	7.	33.	1175.	98.	27568.	3856897.
10	7.	34.	1196.	100.	28054.	3925619.
11	7.	34.	1211.	101.	28415.	3976793.
12	7.	34.	1223.	102.	28684.	4014870.
13	7.	34.	1232.	103.	28885.	4043356.
14	7.	34.	1238.	103.	29029.	4063770.
15	7.	34.	1242.	104.	29128.	4077826.
16	7.	34.	1245.	104.	29190.	4086587.
17	7.	34.	1246.	104.	29225.	4091623.
18	7.	34.	1247.	104.	29239.	4093692.
19	7.	34.	1246.	104.	29223.	4091690.

Relevant projections for the base program model for dairy herds are itemized in Table 19-D (dairy)--again, first for the total U. S. and then for each region, in turn. Whereas, infection in beef herds stabilized under the base program, infection in dairy herds trended slightly downward, particularly in terms of both numbers of undetected, infected herds and numbers of infected cows. Similarly, annual milk loss declined slightly from 38.1 million pounds in year 0 to 26.8 million pounds in year 19, with similar declines in calf losses. However, the number of quarantined herds declined very little.

2. The Accelerated Program

The accelerated program was designed to approximate the APHIS "10-year accelerated brucellosis eradication" program, with a few slight modifications to accomodate our regional model specifications. Under this option, the high prevalence states comprising Regions 3, 4, and 5 were placed under area testing programs. Prior to area testing, first point of concentration (FPC) testing was completed. Whereas the APHIS model initiated area testing by states, in our regional model we assumed that testing proceeded on a regional basis as follows:

(1) Area testing was initiated in Region 3 in year 2 of the program (1978) covering one-third of the region each year, with area testing being completed in year 4.

(2) Region 5 entered into area testing in year 4, covering one-third of the area by per year and completed area testing in year 6.

(3) Area testing was started in Region 4 in year 5 and completed in year 7.

Infection levels, including physical losses, under the accelerated program are shown in the Table 20 series. It is reasonable to expect that during the period when the accelerated program was being carried out in the region, the level of quality control[1] was expected to increase materially due to increased understanding and awareness of the program. However, in the real world it will take an active program of education and promotion to maintain that higher level of awareness and quality control after area testing is completed.

The infection and loss data in Table 20-B-1 were projected for beef under the assumption that the high level of program quality would be maintained in each region after area testing was completed. The number of infected herds was reduced sharply and steadily over the period--especially for undetected infected herds. Similarly, the number of infected cows was greatly reduced--in both quarantined and undetected herds. Annual beef losses by year 19 were reduced to just over 10 percent of the annual losses when the program started.

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[1] Quality control relates to the extent of cooperation between state and federal workers, industry representatives and producers, as well as quality of performance. Its role in the simulation model is discussed in Annex 1.

TABLE 20-B-1

****************** NBTC SIMULATION MODEL ******************

•••••• BEEF MODEL ••• ACCELERATED PROGRAM #1 ••••••••

***************** U. S. T O T A L S**********************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	20465.	15014.	452329.	111862.	80253744.
1	19183.	16637.	365844.	96270.	66324384.
2	18627.	15494.	339200.	94667.	63076448.
3	18251.	14923.	343004.	95797.	63804736.
4	17010.	15671.	380111.	85747.	67170224.
5	14959.	15528.	353226.	73554.	61267120.
6	14163.	12893.	293990.	67218.	52164144.
7	13137.	11803.	265052.	61257.	47148576.
8	10948.	12087.	255976.	50601.	43811056.
9	8924.	10940.	219585.	40517.	37074048.
10	8211.	8212.	166589.	36758.	29261904.
11	7540.	7059.	146665.	33840.	26005376.
12	6718.	6559.	135770.	30082.	23827824.
13	5543.	6348.	127092.	24660.	21660608.
14	5074.	4962.	99374.	22373.	17510896.
15	4538.	4418.	89696.	20126.	15799832.
16	3874.	4138.	82929.	17190.	14324631.
17	3370.	3564.	70793.	14791.	12242835.
18	2620.	3390.	64787.	11520.	10864828.
19	2287.	2546.	49115.	9973.	8458692.

**************** R E G I O N 1 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	148.	150.	2593.	570.	457179.
1	150.	150.	2022.	565.	383536.
2	144.	144.	2007.	556.	381058.
3	141.	137.	2016.	555.	381224.
4	151.	121.	1834.	602.	365557.
5	151.	131.	2048.	609.	395556.
6	160.	121.	1919.	647.	384462.
7	165.	124.	2006.	672.	400532.
8	143.	153.	2405.	573.	435883.
9	114.	147.	2158.	451.	379654.
10	105.	108.	1549.	412.	289263.
11	98.	92.	1364.	386.	258716.
12	87.	89.	1320.	344.	244346.
13	72.	87.	1248.	280.	223003.
14	65.	67.	957.	253.	178224.
15	58.	60.	863.	227.	160450.
16	50.	55.	800.	196.	145946.
17	44.	48.	681.	172.	125223.
18	31.	49.	689.	119.	116160.
19	28.	32.	427.	106.	78244.

TABLE 20-B-1 (continued)

***************** NBTC SIMULATION MODEL ******************

...... BEEF MODEL ... ACCELERATED PROGRAM #1 ....

**************** R E G I O N 2 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	38.	27.	324.	97.	61575.
1	43.	37.	430.	122.	81732.
2	43.	41.	514.	131.	94714.
3	44.	40.	530.	135.	97615.
4	48.	36.	492.	152.	95608.
5	50.	41.	574.	158.	107765.
6	55.	40.	554.	176.	108575.
7	59.	42.	605.	190.	117959.
8	53.	54.	750.	164.	132325.
9	45.	52.	659.	135.	114580.
10	43.	40.	498.	127.	91077.
11	42.	35.	443.	125.	83141.
12	39.	35.	448.	115.	81841.
13	33.	35.	431.	99.	76552.
14	31.	28.	349.	92.	64103.
15	29.	26.	326.	84.	59624.
16	25.	25.	305.	75.	54972.
17	23.	22.	266.	67.	48394.
18	18.	22.	267.	52.	45687.
19	16.	16.	188.	46.	34039.

**************** R E G I O N 3 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	5092.	3462.	79878.	20316.	14331217.
1	4295.	4730.	76503.	15294.	13050330.
2	3715.	4524.	64824.	12828.	11075512.
3	3369.	3990.	57275.	11674.	9863610.
4	3464.	3272.	48134.	12554.	8848633.
5	3503.	3000.	47114.	13177.	8815218.
6	3600.	2759.	45160.	13764.	8637271.
7	3621.	2742.	45772.	13911.	8731364.
8	3105.	3231.	52539.	11523.	9168015.
9	2634.	3092.	45945.	9463.	7906394.
10	2444.	2485.	36154.	8639.	6436621.
11	2295.	2137.	31688.	8124.	5724932.
12	2084.	2002.	29955.	7313.	5341745.
13	1803.	1917.	27828.	6284.	4875684.
14	1658.	1599.	22998.	5764.	4129565.
15	1507.	1435.	20932.	5249.	3757298.
16	1337.	1327.	19272.	4652.	3427676.
17	1198.	1175.	16907.	4172.	3022910.
18	954.	1163.	16366.	3308.	2802632.
19	851.	900.	12525.	2926.	2214377.

TABLE 20-B-1 (continued)

***************** NBTC SIMULATION MODEL *****************

•••••• BEEF MODEL ••• ACCELERATED PROGRAM #1 ••••••••

****************** R E G I O N 4 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	1149.	587.	31204.	8718.	5658272.
1	1133.	609.	24849.	7727.	4649237.
2	1124.	602.	24632.	7721.	4675609.
3	1128.	591.	26045.	8044.	4918331.
4	1175.	558.	26554.	8560.	5075757.
5	1198.	598.	28702.	8891.	5421304.
6	1074.	767.	36032.	7139.	6113075.
7	956.	738.	29370.	5827.	4989448.
8	780.	727.	25312.	4605.	4235029.
9	614.	635.	20900.	3622.	3469977.
10	569.	427.	15669.	3255.	2698257.
11	526.	362.	13497.	2961.	2349958.
12	471.	340.	12269.	2627.	2121996.
13	404.	324.	11125.	2248.	1900671.
14	366.	264.	9359.	2018.	1621667.
15	328.	237.	8356.	1802.	1447774.
16	288.	218.	7534.	1584.	1297891.
17	257.	190.	6609.	1406.	1141785.
18	206.	190.	6142.	1155.	1035144.
19	183.	144.	4978.	1018.	853749.

****************** R E G I O N 5 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	12872.	9396.	299015.	76189.	53320768.
1	12460.	9539.	234687.	67333.	43430528.
2	12583.	8675.	219957.	68377.	42139920.
3	12614.	8695.	229385.	70476.	43795008.
4	11150.	10350.	277265.	58470.	48180704.
5	9124.	10363.	246096.	45680.	41623456.
6	8348.	7974.	185852.	40515.	32604448.
7	7441.	7013.	163580.	35828.	28724352.
8	6164.	6680.	149864.	29937.	25687136.
9	4965.	5911.	129659.	23921.	21879312.
10	4549.	4323.	97656.	21724.	17188368.
11	4128.	3734.	86362.	19900.	15319197.
12	3637.	3463.	79787.	17599.	13998677.
13	2912.	3388.	75285.	14074.	12737524.
14	2663.	2529.	57037.	12739.	10042441.
15	2358.	2249.	51402.	11418.	9047259.
16	1960.	2129.	47812.	9570.	8200988.
17	1666.	1803.	40331.	8034.	6905469.
18	1274.	1670.	35947.	6176.	5995372.
19	1091.	1227.	27054.	5268.	4622796.

TABLE 20-B-1 (continued)

***************** NBTC SIMULATION MODEL *****************

...... BEEF MODEL ... ACCELERATED PROGRAM #1 ....

**************** R E G I O N 6 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	735.	1050.	27961.	4003.	4527851.
1	721.	1149.	19842.	3643.	3416040.
2	676.	1115.	20099.	3567.	3454722.
3	644.	1099.	20522.	3483.	3495035.
4	714.	995.	18888.	3951.	3379924.
5	654.	1062.	21450.	3668.	3657797.
6	661.	934.	18086.	3676.	3200743.
7	647.	874.	17704.	3606.	3134658.
8	494.	969.	19186.	2763.	3152993.
9	382.	849.	15183.	2099.	2479268.
10	350.	627.	11205.	1889.	1900348.
11	316.	532.	9968.	1707.	1695406.
12	282.	481.	8971.	1525.	1523633.
13	219.	461.	8479.	1197.	1390564.
14	202.	359.	6406.	1088.	1088097.
15	180.	313.	5836.	977.	988851.
16	145.	295.	5442.	794.	897128.
17	123.	250.	4469.	663.	738771.
18	91.	222.	3972.	496.	639142.
19	78.	170.	2919.	424.	481482.

**************** R E G I O N 7 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	407.	323.	10910.	1900.	1823039.
1	358.	400.	7100.	1510.	1242884.
2	319.	369.	6676.	1410.	1172652.
3	290.	344.	6699.	1352.	1165859.
4	285.	312.	6415.	1370.	1134487.
5	258.	307.	6664.	1285.	1150282.
6	243.	273.	5862.	1215.	1026915.
7	227.	247.	5498.	1138.	963162.
8	191.	247.	5382.	967.	913062.
9	154.	231.	4635.	773.	773682.
10	136.	184.	3526.	662.	602908.
11	122.	151.	3044.	589.	524074.
12	106.	134.	2731.	516.	467933.
13	90.	122.	2430.	442.	413180.
14	78.	103.	2052.	384.	350773.
15	69.	88.	1781.	335.	304921.
16	59.	78.	1576.	290.	268660.
17	51.	68.	1364.	251.	232392.
18	39.	64.	1240.	193.	204465.
19	34.	49.	901.	165.	153299.

TABLE 20-B-1 (continued)

**************** NBTC SIMULATION MODEL ****************

•••••• BEEF MODEL ••• ACCELERATED PROGRAM #1 ••••••••

**************** R E G I O N 8 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	24.	20.	446.	69.	73887.
1	23.	25.	409.	74.	70118.
2	22.	27.	493.	78.	82300.
3	21.	27.	532.	79.	88087.
4	22.	26.	529.	88.	89575.
5	22.	27.	579.	85.	95773.
6	22.	25.	525.	87.	88677.
7	22.	24.	517.	85.	87127.
8	18.	26.	538.	69.	86632.
9	15.	24.	447.	54.	71204.
10	14.	19.	334.	50.	55088.
11	14.	16.	298.	48.	49989.
12	13.	15.	288.	44.	47688.
13	11.	15.	267.	37.	43467.
14	10.	12.	216.	35.	36038.
15	10.	11.	201.	32.	33657.
16	9.	11.	189.	29.	31371.
17	8.	10.	167.	27.	27892.
18	7.	10.	163.	21.	26228.
19	7.	8.	123.	20.	20710.

TABLE 20-D-1

**************** NBTC SIMULATION MODEL ****************

...... DAIRY MODEL ... ACCELERATED PROGRAM #1 ....

**************** U. S. T O T A L S**********************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	209.	835.	16800.	1400.	403522.	38057984.
1	165.	815.	15423.	1285.	363686.	35278160.
2	151.	765.	12557.	1046.	298034.	28621200.
3	142.	710.	11507.	959.	273561.	26346896.
4	137.	681.	10960.	913.	260631.	25205040.
5	131.	651.	10527.	877.	250380.	24289856.
6	123.	610.	10091.	841.	239906.	23397104.
7	115.	573.	9631.	803.	228887.	22445584.
8	108.	540.	9155.	763.	217522.	21438960.
9	98.	494.	8545.	712.	202869.	20118112.
10	86.	435.	7763.	647.	184101.	18405408.
11	76.	385.	6989.	582.	165679.	16703357.
12	69.	348.	6341.	528.	150323.	15274582.
13	63.	315.	5797.	483.	137413.	14075197.
14	55.	280.	5272.	439.	124900.	12916282.
15	50.	250.	4793.	399.	113506.	11856790.
16	45.	226.	4379.	365.	103674.	10938302.
17	40.	202.	4006.	334.	94821.	10112197.
18	36.	181.	3666.	305.	86716.	9356069.
19	31.	158.	3323.	277.	78543.	8594809.

**************** R E G I O N 1 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	26.	103.	1605.	134.	38659.	4047638.
1	18.	86.	1288.	107.	30618.	3246943.
2	15.	72.	1042.	87.	24874.	2627201.
3	13.	63.	905.	75.	21626.	2281256.
4	12.	58.	814.	68.	19464.	2051385.
5	12.	56.	763.	64.	18271.	1923304.
6	12.	54.	734.	61.	17595.	1850850.
7	12.	54.	723.	60.	17334.	1822296.
8	12.	54.	723.	60.	17340.	1822197.
9	11.	52.	700.	58.	16783.	1765173.
10	10.	46.	642.	54.	15371.	1619130.
11	9.	41.	577.	48.	13805.	1455009.
12	8.	38.	521.	43.	12479.	1314952.
13	7.	34.	472.	39.	11297.	1190345.
14	6.	30.	419.	35.	10025.	1056933.
15	6.	26.	370.	31.	8859.	934129.
16	5.	23.	329.	27.	7862.	828814.
17	4.	21.	291.	24.	6953.	733114.
18	4.	18.	256.	21.	6127.	646077.
19	3.	15.	218.	18.	5220.	550973.

TABLE 20-D-1 (continued)

**************** NBTC SIMULATION MODEL ****************

...... DAIRY MODEL ... ACCELERATED PROGRAM #1 ....

**************** R E G I O N 2 T O T A L S************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	2.	10.	61.	5.	1474.	147641.
1	1.	6.	58.	5.	1393.	141481.
2	1.	5.	53.	4.	1269.	129311.
3	1.	5.	48.	4.	1143.	116473.
4	1.	4.	44.	4.	1044.	106251.
5	1.	4.	41.	3.	986.	100234.
6	1.	4.	40.	3.	957.	97166.
7	1.	4.	40.	3.	956.	97024.
8	1.	5.	41.	3.	976.	98938.
9	1.	5.	40.	3.	967.	98103.
10	1.	4.	38.	3.	914.	92879.
11	1.	4.	36.	3.	851.	86518.
12	1.	4.	33.	3.	796.	80880.
13	1.	3.	31.	3.	743.	75471.
14	1.	3.	28.	2.	679.	69051.
15	1.	3.	26.	2.	619.	62955.
16	1.	3.	24.	2.	564.	57389.
17	0.	2.	21.	2.	511.	52001.
18	0.	2.	19.	2.	461.	46933.
19	0.	2.	17.	1.	402.	40988.

**************** R E G I O N 3 T O T A L S************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	79.	314.	5207.	434.	125173.	10443844.
1	46.	240.	3957.	330.	93406.	7933941.
2	36.	185.	2916.	243.	69182.	5845860.
3	30.	153.	2399.	200.	57035.	4809083.
4	26.	132.	2053.	171.	48830.	4115236.
5	24.	120.	1824.	152.	43446.	3656639.
6	23.	114.	1690.	141.	40294.	3387256.
7	23.	111.	1616.	135.	38581.	3240413.
8	23.	110.	1575.	131.	37606.	3157028.
9	21.	104.	1507.	126.	35977.	3021983.
10	19.	94.	1392.	116.	33189.	2791028.
11	17.	85.	1263.	105.	30101.	2532498.
12	16.	77.	1148.	96.	27349.	2300620.
13	14.	70.	1044.	87.	24885.	2093192.
14	13.	63.	941.	78.	22411.	1885751.
15	11.	56.	844.	70.	20118.	1692926.
16	10.	51.	760.	63.	18098.	1522809.
17	9.	46.	682.	57.	16248.	1367201.
18	8.	41.	610.	51.	14544.	1223965.
19	7.	35.	536.	45.	12752.	1073834.

TABLE 20-D-1 (continued)

**************** NBTC SIMULATION MODEL ****************

...... DAIRY MODEL ... ACCELERATED PROGRAM #1 ....

**************** R E G I O N 4 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	19.	77.	5341.	445.	127983.	12591584.
1	10.	71.	4966.	414.	115681.	11701157.
2	7.	71.	3202.	267.	74806.	7545562.
3	6.	53.	2371.	198.	55758.	5587912.
4	6.	46.	2042.	170.	48135.	4811906.
5	6.	43.	1884.	157.	44488.	4439650.
6	6.	42.	1816.	151.	42935.	4279854.
7	5.	41.	1759.	147.	41565.	4144653.
8	5.	38.	1667.	139.	39349.	3927620.
9	4.	35.	1526.	127.	35993.	3596252.
10	4.	30.	1348.	112.	31762.	3177397.
11	3.	26.	1172.	98.	27610.	2762573.
12	3.	23.	1030.	86.	24279.	2427403.
13	3.	21.	921.	77.	21723.	2170968.
14	2.	18.	825.	69.	19448.	1944016.
15	2.	16.	736.	61.	17341.	1733653.
16	2.	15.	656.	55.	15466.	1546031.
17	2.	13.	586.	49.	13807.	1380210.
18	1.	12.	522.	44.	12306.	1230236.
19	1.	10.	460.	38.	10829.	1083152.

**************** R E G I O N 5 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	51.	205.	2840.	237.	68287.	6042082.
1	64.	292.	3277.	273.	78322.	6968174.
2	67.	317.	3672.	306.	88069.	7809497.
3	68.	326.	4023.	335.	96183.	8555125.
4	69.	333.	4209.	351.	100550.	8951601.
5	66.	322.	4215.	351.	100558.	8963590.
6	59.	293.	4004.	334.	95364.	8515425.
7	53.	262.	3686.	307.	87715.	7839981.
8	47.	236.	3351.	279.	79709.	7126558.
9	42.	208.	3003.	250.	71400.	6386803.
10	35.	177.	2631.	219.	62506.	5595869.
11	30.	153.	2290.	191.	54381.	4869603.
12	27.	135.	2009.	167.	47721.	4271660.
13	24.	120.	1773.	148.	42143.	3771607.
14	21.	104.	1550.	129.	36824.	3296932.
15	18.	90.	1350.	113.	32066.	2871371.
16	16.	79.	1181.	98.	28054.	2511600.
17	14.	69.	1031.	86.	24489.	2192648.
18	12.	59.	894.	75.	21231.	1901451.
19	10.	49.	761.	63.	18062.	1618708.

TABLE 20-D-1 (continued)

***************** NBTC SIMULATION MODEL ******************

...... DAIRY MODEL ... ACCELERATED PROGRAM #1 ....

***************** R E G I O N 6 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	14.	55.	524.	44.	12625.	1170281.
1	15.	69.	573.	48.	13766.	1278924.
2	15.	69.	609.	51.	14653.	1359841.
3	14.	67.	607.	51.	14577.	1356947.
4	13.	64.	583.	49.	13993.	1303267.
5	13.	63.	566.	47.	13568.	1263181.
6	13.	60.	541.	45.	12983.	1209033.
7	12.	57.	517.	43.	12410.	1155763.
8	12.	55.	496.	41.	11895.	1107664.
9	10.	50.	457.	38.	10956.	1021215.
10	9.	42.	402.	33.	9618.	897795.
11	8.	37.	350.	29.	8363.	780946.
12	7.	32.	307.	26.	7351.	686230.
13	6.	29.	272.	23.	6522.	608636.
14	5.	25.	238.	20.	5687.	530975.
15	4.	21.	207.	17.	4960.	463146.
16	4.	19.	182.	15.	4361.	407088.
17	3.	16.	159.	13.	3809.	355680.
18	3.	14.	138.	11.	3298.	308027.
19	2.	12.	117.	10.	2787.	260491.

***************** R E G I O N 7 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	14.	54.	791.	66.	18977.	2197087.
1	6.	30.	541.	45.	12702.	1504141.
2	4.	21.	368.	31.	8697.	1022447.
3	3.	16.	298.	25.	7054.	828232.
4	3.	14.	250.	21.	5914.	693734.
5	3.	13.	217.	18.	5158.	604185.
6	2.	12.	194.	16.	4613.	539923.
7	2.	11.	176.	15.	4190.	490246.
8	2.	10.	162.	13.	3847.	449927.
9	2.	9.	147.	12.	3501.	409616.
10	2.	8.	131.	11.	3118.	365084.
11	1.	7.	116.	10.	2751.	322302.
12	1.	6.	103.	9.	2432.	284895.
13	1.	5.	91.	8.	2155.	252390.
14	1.	5.	80.	7.	1899.	222557.
15	1.	4.	71.	6.	1673.	196039.
16	1.	3.	62.	5.	1476.	172946.
17	1.	3.	55.	5.	1302.	152616.
18	1.	3.	48.	4.	1149.	134625.
19	0.	2.	42.	4.	998.	117040.

TABLE 20-D-1 (continued)

**************** NBTC SIMULATION MODEL ****************

•••••• DAIRY MODEL ••• ACCELERATED PROGRAM #1 ••••••••

**************** R E G I O N 8 T O T A L S************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	4.	17.	432.	36.	10343.	1417862.
1	5.	21.	763.	64.	17799.	2503442.
2	6.	26.	695.	58.	16485.	2281511.
3	6.	27.	856.	71.	20184.	2811894.
4	6.	29.	966.	81.	22701.	3171681.
5	6.	30.	1017.	85.	23905.	3339119.
6	7.	31.	1071.	89.	25166.	3517619.
7	7.	32.	1113.	93.	26136.	3655232.
8	7.	32.	1142.	95.	26799.	3749047.
9	7.	33.	1163.	97.	27292.	3818973.
10	7.	33.	1178.	98.	27624.	3866243.
11	7.	33.	1186.	99.	27817.	3893910.
12	7.	33.	1190.	99.	27915.	3907942.
13	7.	33.	1192.	99.	27946.	3912589.
14	7.	33.	1191.	99.	27926.	3910068.
15	7.	33.	1189.	99.	27872.	3902572.
16	7.	33.	1185.	99.	27793.	3891628.
17	7.	33.	1181.	98.	27701.	3878728.
18	7.	32.	1177.	98.	27601.	3864755.
19	7.	32.	1173.	98.	27493.	3849624.

TABLE 20-B-2

***************** NBTC SIMULATION MODEL *****************

•••••• BEEF MODEL ••• ACCELERATED PROGRAM #2 ••••••••

**************** U. S. T O T A L S*********************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	20465.	15014.	452329.	111862.	80253744.
1	19183.	16637.	365844.	96270.	66324384.
2	18627.	15494.	339200.	94667.	63076448.
3	18251.	14923.	343004.	95797.	63804736.
4	17010.	15671.	380111.	85747.	67170224.
5	14959.	15528.	353226.	73554.	61267120.
6	14163.	12893.	293990.	67218.	52164144.
7	13137.	11803.	265052.	61257.	47148576.
8	10948.	12087.	255976.	50601.	43811056.
9	8924.	10940.	219585.	40517.	37074048.
10	8537.	7886.	161398.	38488.	28884960.
11	8711.	6247.	133313.	41182.	25538352.
12	8655.	6320.	141855.	42627.	26906816.
13	8060.	6981.	156907.	40501.	28528016.
14	8197.	6165.	141480.	41542.	26661808.
15	8175.	6214.	146488.	42084.	27465008.
16	7861.	6560.	153285.	40992.	28137056.
17	7700.	6362.	148724.	40217.	27372512.
18	6919.	6844.	156450.	36292.	27757968.
19	6802.	5878.	135558.	35736.	24827392.

**************** R E G I O N 1 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	148.	150.	2593.	570.	457179.
1	150.	150.	2022.	565.	383536.
2	144.	144.	2007.	556.	381058.
3	141.	137.	2016.	555.	381224.
4	151.	121.	1834.	602.	365557.
5	151.	131.	2048.	609.	395556.
6	160.	121.	1919.	647.	384462.
7	165.	124.	2006.	672.	400532.
8	143.	153.	2405.	573.	435883.
9	114.	147.	2158.	451.	379654.
10	105.	108.	1549.	412.	289263.
11	99.	92.	1372.	389.	260391.
12	90.	91.	1352.	352.	250582.
13	76.	91.	1320.	296.	236203.
14	71.	74.	1062.	279.	197873.
15	67.	69.	1012.	264.	188394.
16	61.	68.	1001.	241.	182763.
17	58.	63.	916.	227.	168607.
18	44.	70.	1007.	169.	169345.
19	43.	50.	681.	164.	124794.

TABLE 20-B-2 (continued)

***************** NBTC SIMULATION MODEL *****************

...... BEEF MODEL ... ACCELERATED PROGRAM #2 ....

**************** R E G I O N 2 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	38.	27.	324.	97.	61575.
1	43.	37.	430.	122.	81732.
2	43.	41.	514.	131.	94714.
3	44.	40.	530.	135.	97615.
4	48.	36.	492.	152.	95608.
5	50.	41.	574.	158.	107765.
6	55.	40.	554.	176.	108575.
7	59.	42.	605.	190.	117959.
8	53.	54.	750.	164.	132325.
9	45.	52.	659.	135.	114580.
10	43.	40.	498.	127.	91077.
11	42.	35.	454.	127.	85087.
12	40.	37.	475.	120.	86672.
13	36.	38.	478.	107.	84783.
14	35.	33.	411.	104.	75155.
15	33.	32.	409.	101.	74281.
16	31.	32.	408.	94.	72999.
17	30.	30.	383.	90.	68917.
18	25.	33.	411.	74.	69819.
19	24.	26.	318.	72.	56951.

**************** R E G I O N 3 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	5092.	3462.	79878.	20316.	14331217.
1	4295.	4730.	76503.	15294.	13050330.
2	3715.	4524.	64824.	12828.	11075512.
3	3369.	3990.	57275.	11674.	9863610.
4	3464.	3272.	48134.	12554.	8848633.
5	3503.	3000.	47114.	13177.	8815218.
6	3600.	2759.	45160.	13764.	8637271.
7	3621.	2742.	45772.	13911.	8731364.
8	3105.	3231.	52539.	11523.	9168015.
9	2634.	3092.	45945.	9463.	7906394.
10	2771.	2158.	30963.	10370.	6059689.
11	2802.	1979.	32140.	10804.	6265815.
12	2771.	2043.	34205.	10716.	6520610.
13	2646.	2166.	35523.	10188.	6612873.
14	2656.	2008.	32510.	10264.	6225500.
15	2637.	1999.	33133.	10228.	6303154.
16	2578.	2038.	33639.	10003.	6333975.
17	2545.	1994.	32644.	9904.	6184585.
18	2302.	2172.	35093.	8903.	6344435.
19	2261.	1901.	30211.	8706.	5649452.

TABLE 20-B-2 (continued)

***************** NBTC SIMULATION MODEL *****************

•••••• BEEF MODEL ••• ACCELERATED PROGRAM #2 ••••••••

**************** R E G I O N 4 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	1149.	587.	31204.	8718.	5658272.
1	1133.	609.	24849.	7727.	4649237.
2	1124.	602.	24632.	7721.	4675609.
3	1128.	591.	26045.	8044.	4918331.
4	1175.	558.	26554.	8560.	5075757.
5	1198.	598.	28702.	8891.	5421304.
6	1074.	767.	36032.	7139.	6113075.
7	956.	738.	29370.	5827.	4989448.
8	780.	727.	25312.	4605.	4235029.
9	614.	635.	20900.	3622.	3469977.
10	569.	427.	15669.	3255.	2698257.
11	526.	363.	13510.	2963.	2352116.
12	540.	273.	10156.	3353.	1965131.
13	525.	292.	11931.	3534.	2232888.
14	530.	277.	12361.	3735.	2321743.
15	533.	285.	13081.	3870.	2442357.
16	528.	299.	13760.	3932.	2544728.
17	527.	299.	14001.	3997.	2588904.
18	492.	336.	14859.	3850.	2679386.
19	491.	298.	14046.	3857.	2571604.

**************** R E G I O N 5 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	12872.	9396.	299015.	76189.	53320768.
1	12460.	9539.	234687.	67333.	43430528.
2	12563.	8675.	219957.	68377.	42139920.
3	12614.	8695.	229385.	70476.	43795008.
4	11150.	10350.	277265.	58470.	48180704.
5	9124.	10363.	246096.	45680.	41623456.
6	8348.	7974.	185852.	40515.	32604448.
7	7441.	7013.	163580.	35828.	28724352.
8	6164.	6680.	149864.	29937.	25687136.
9	4965.	5911.	129659.	23921.	21879312.
10	4549.	4323.	97656.	21724.	17188368.
11	4787.	3075.	72442.	24541.	14290385.
12	4794.	3217.	83035.	25893.	15932321.
13	4422.	3719.	94893.	24487.	17250336.
14	4556.	3190.	84207.	25300.	15981866.
15	4566.	3266.	87882.	25789.	16595028.
16	4358.	3538.	93160.	25050.	17127712.
17	4254.	3420.	90208.	24427.	16607251.
18	3815.	3672.	94435.	21962.	16776978.
19	3750.	3115.	81395.	21643.	14950114.

TABLE 20-B-2 (continued)

***************** NBTC SIMULATION MODEL *****************

...... BEEF MODEL ... ACCELERATED PROGRAM #2 ....

**************** R E G I O N 6 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	735.	1050.	27961.	4003.	4527851.
1	721.	1149.	19842.	3643.	3416040.
2	676.	1115.	20099.	3567.	3454722.
3	644.	1099.	20522.	3483.	3495035.
4	714.	995.	18888.	3951.	3379924.
5	654.	1062.	21450.	3668.	3657797.
6	661.	934.	18086.	3676.	3200743.
7	647.	874.	17704.	3606.	3134658.
8	494.	969.	19186.	2763.	3152993.
9	382.	849.	15183.	2099.	2479268.
10	350.	627.	11205.	1889.	1900348.
11	319.	536.	10054.	1721.	1710512.
12	298.	507.	9523.	1617.	1619848.
13	248.	527.	9796.	1367.	1607969.
14	250.	450.	8209.	1371.	1395707.
15	246.	437.	8350.	1365.	1415123.
16	218.	462.	8730.	1227.	1437023.
17	205.	437.	8075.	1148.	1332304.
18	173.	438.	8098.	974.	1301831.
19	168.	382.	6820.	948.	1122928.

**************** R E G I O N 7 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	407.	323.	10910.	1900.	1823039.
1	358.	400.	7100.	1510.	1242884.
2	319.	369.	6676.	1410.	1172652.
3	290.	344.	6699.	1352.	1165859.
4	285.	312.	6415.	1370.	1134487.
5	258.	307.	6664.	1285.	1150282.
6	243.	273.	5862.	1215.	1026915.
7	227.	247.	5498.	1138.	963162.
8	191.	247.	5382.	967.	913062.
9	154.	231.	4635.	773.	773682.
10	136.	184.	3526.	662.	602908.
11	122.	151.	3044.	589.	524074.
12	109.	138.	2813.	532.	482770.
13	96.	133.	2676.	483.	456119.
14	88.	121.	2473.	451.	422664.
15	83.	113.	2373.	430.	405467.
16	77.	111.	2335.	409.	396771.
17	72.	106.	2259.	389.	382912.
18	59.	110.	2302.	332.	377095.
19	57.	95.	1888.	317.	318750.

TABLE 20-B-2 (continued)

***************** NBTC SIMULATION MODEL *****************

...... BEEF MCDEL ... ACCELERATED PROGRAM #2 ....

****************** R E G I O N 8 T O T A L S***************

YEAR	UNDETECTED INF.HERDS	GUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	24.	20.	446.	69.	73887.
1	23.	25.	409.	74.	70118.
2	22.	27.	493.	78.	82300.
3	21.	27.	532.	79.	88087.
4	22.	26.	529.	88.	89575.
5	22.	27.	579.	85.	95773.
6	22.	25.	525.	87.	88677.
7	22.	24.	517.	85.	87127.
8	18.	26.	538.	69.	86632.
9	15.	24.	447.	54.	71204.
10	14.	19.	334.	50.	55088.
11	14.	16.	298.	48.	49989.
12	13.	15.	296.	45.	48909.
13	11.	16.	289.	39.	46867.
14	11.	14.	248.	38.	41334.
15	11.	13.	248.	38.	41245.
16	10.	13.	251.	36.	41107.
17	10.	13.	237.	34.	39056.
18	9.	14.	246.	29.	39114.
19	8.	12.	200.	28.	32831.

TABLE 20-D-2

***************** NBTC SIMULATION MODEL *****************

...... DAIRY MODEL ... ACCELERATED PROGRAM #2 ....

**************** U. S. T O T A L S***********************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	209.	835.	16800.	1400.	403522.	38057984.
1	165.	815.	15423.	1285.	363686.	35278160.
2	151.	765.	12557.	1046.	298034.	28621200.
3	142.	710.	11507.	959.	273561.	26346896.
4	137.	681.	10960.	913.	260631.	25205040.
5	131.	651.	10527.	877.	250380.	24289856.
6	123.	610.	10091.	841.	239906.	23397104.
7	115.	573.	9631.	803.	228887.	22445584.
8	108.	540.	9155.	763.	217522.	21438960.
9	98.	494.	8545.	712.	202869.	20118112.
10	86.	435.	7763.	647.	184101.	18405408.
11	77.	388.	7015.	585.	166320.	16755980.
12	73.	363.	6471.	539.	153515.	15545132.
13	70.	348.	6125.	510.	145403.	14768110.
14	67.	333.	5861.	488.	139139.	14171827.
15	65.	323.	5672.	473.	134672.	13744271.
16	64.	317.	5549.	462.	131795.	13463817.
17	63.	310.	5449.	454.	129402.	13233496.
18	61.	303.	5352.	446.	127101.	13014519.
19	58.	288.	5195.	433.	123290.	12661515.

**************** R E G I O N 1 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	26.	103.	1605.	134.	38659.	4047638.
1	18.	86.	1288.	107.	30618.	3246943.
2	15.	72.	1042.	87.	24874.	2627201.
3	13.	63.	905.	75.	21626.	2281256.
4	12.	58.	814.	68.	19464.	2051385.
5	12.	56.	763.	64.	18271.	1923304.
6	12.	54.	734.	61.	17595.	1850850.
7	12.	54.	723.	60.	17334.	1822296.
8	12.	54.	723.	60.	17340.	1822197.
9	11.	52.	700.	58.	16783.	1765173.
10	10.	46.	642.	54.	15371.	1619130.
11	9.	41.	578.	48.	13817.	1456248.
12	8.	38.	524.	44.	12551.	1322350.
13	7.	35.	481.	40.	11508.	1212104.
14	7.	31.	436.	36.	10443.	1100312.
15	6.	29.	399.	33.	9551.	1006165.
16	6.	27.	370.	31.	8865.	933460.
17	5.	25.	346.	29.	8287.	872493.
18	5.	24.	325.	27.	7794.	820455.
19	5.	21.	298.	25.	7130.	751120.

TABLE 20-D-2 (continued)

***************** NBTC SIMULATION MODEL *****************

•••••• DAIRY MODEL ••• ACCELERATED PROGRAM #2 ••••••••

***************** R E G I O N 2 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	2.	10.	61.	5.	1474.	147641.
1	1.	6.	58.	5.	1393.	141481.
2	1.	5.	53.	4.	1269.	129311.
3	1.	5.	48.	4.	1143.	116473.
4	1.	4.	44.	4.	1044.	106251.
5	1.	4.	41.	3.	986.	100234.
6	1.	4.	40.	3.	957.	97166.
7	1.	4.	40.	3.	956.	97024.
8	1.	5.	41.	3.	976.	98938.
9	1.	5.	40.	3.	967.	98103.
10	1.	4.	38.	3.	914.	92879.
11	1.	4.	36.	3.	853.	86682.
12	1.	4.	34.	3.	803.	81595.
13	1.	4.	32.	3.	761.	77273.
14	1.	3.	30.	2.	712.	72398.
15	1.	3.	28.	2.	672.	68264.
16	1.	3.	27.	2.	639.	64945.
17	1.	3.	26.	2.	609.	61900.
18	1.	3.	24.	2.	583.	59164.
19	1.	2.	23.	2.	542.	55044.

***************** R E G I O N 3 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	79.	314.	5207.	434.	125173.	10443844.
1	46.	240.	3957.	330.	93406.	7933941.
2	36.	185.	2916.	243.	69182.	5845860.
3	30.	153.	2399.	200.	57035.	4809083.
4	26.	132.	2053.	171.	48830.	4115236.
5	24.	120.	1824.	152.	43446.	3656639.
6	23.	114.	1690.	141.	40294.	3387256.
7	23.	111.	1616.	135.	38581.	3240413.
8	23.	110.	1575.	131.	37606.	3157028.
9	21.	104.	1507.	126.	35977.	3021983.
10	19.	94.	1392.	116.	33189.	2791028.
11	18.	87.	1288.	107.	30714.	2582461.
12	17.	85.	1222.	102.	29166.	2450035.
13	17.	83.	1181.	98.	28202.	2367788.
14	17.	80.	1143.	95.	27303.	2292280.
15	16.	79.	1113.	93.	26592.	2232155.
16	16.	78.	1093.	91.	26104.	2190595.
17	16.	77.	1074.	90.	25670.	2154086.
18	16.	75.	1057.	88.	25261.	2119782.
19	15.	72.	1023.	85.	24434.	2051433.

TABLE 20-D-2 (continued)

**************** NBTC SIMULATION MODEL *****************

...... DAIRY MODEL ... ACCELERATED PROGRAM #2 ....

****************** R E G I O N 4 T O T A L S***************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	19.	77.	5341.	445.	127983.	12591584.
1	10.	71.	4966.	414.	115681.	11701157.
2	7.	71.	3202.	267.	74806.	7545562.
3	6.	53.	2371.	198.	55758.	5587912.
4	6.	46.	2042.	170.	48135.	4811906.
5	6.	43.	1884.	157.	44488.	4439650.
6	6.	42.	1816.	151.	42935.	4279854.
7	5.	41.	1759.	147.	41565.	4144653.
8	5.	38.	1667.	139.	39349.	3927620.
9	4.	35.	1526.	127.	35993.	3596252.
10	4.	30.	1348.	112.	31762.	3177397.
11	3.	26.	1172.	98.	27611.	2762699.
12	3.	23.	1032.	86.	24319.	2431270.
13	3.	21.	944.	79.	22278.	2224317.
14	3.	20.	895.	75.	21145.	2108992.
15	3.	20.	870.	72.	20558.	2049445.
16	3.	20.	856.	71.	20254.	2018333.
17	3.	20.	849.	71.	20083.	2001056.
18	3.	19.	844.	70.	19953.	1988121.
19	3.	19.	831.	69.	19646.	1958211.

****************** R E G I O N 5 T O T A L S***************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	51.	205.	2840.	237.	68287.	6042082.
1	64.	292.	3277.	273.	78322.	6968174.
2	67.	317.	3672.	306.	88069.	7809497.
3	68.	326.	4023.	335.	96183.	8555125.
4	69.	333.	4209.	351.	100550.	8951601.
5	66.	322.	4215.	351.	100558.	8963590.
6	59.	293.	4004.	334.	95364.	8515425.
7	53.	262.	3686.	307.	87715.	7839981.
8	47.	236.	3351.	279.	79709.	7126558.
9	42.	208.	3003.	250.	71400.	6386803.
10	35.	177.	2631.	219.	62506.	5595869.
11	30.	153.	2290.	191.	54381.	4869619.
12	29.	142.	2055.	171.	48870.	4370952.
13	28.	137.	1920.	160.	45706.	4082412.
14	27.	132.	1821.	152.	43386.	3873719.
15	26.	129.	1753.	146.	41772.	3728133.
16	26.	128.	1713.	143.	40849.	3643756.
17	26.	125.	1681.	140.	40077.	3574608.
18	25.	123.	1645.	137.	39224.	3498949.
19	24.	116.	1584.	132.	37743.	3368539.

TABLE 20-D-2 (continued)

**************** NBTC SIMULATION MODEL ****************

...... DAIRY MODEL ... ACCELERATED PROGRAM #2 ....

**************** R E G I O N 6 T O T A L S************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	14.	55.	524.	44.	12625.	1170281.
1	15.	69.	573.	48.	13766.	1278924.
2	15.	69.	609.	51.	14653.	1359841.
3	14.	67.	607.	51.	14577.	1356947.
4	13.	64.	583.	49.	13993.	1303267.
5	13.	63.	566.	47.	13568.	1263181.
6	13.	60.	541.	45.	12983.	1209033.
7	12.	57.	517.	43.	12410.	1155763.
8	12.	55.	496.	41.	11895.	1107664.
9	10.	50.	457.	38.	10956.	1021215.
10	9.	42.	402.	33.	9618.	897795.
11	8.	37.	350.	29.	8375.	782061.
12	7.	33.	311.	26.	7451.	695332.
13	6.	30.	285.	24.	6818.	635700.
14	6.	28.	261.	22.	6248.	582561.
15	5.	26.	244.	20.	5841.	544385.
16	5.	25.	233.	19.	5590.	520617.
17	5.	24.	223.	19.	5354.	498606.
18	5.	23.	213.	18.	5117.	476644.
19	4.	21.	200.	17.	4796.	446934.

**************** R E G I O N 7 T O T A L S************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	14.	54.	791.	66.	18977.	2197087.
1	6.	30.	541.	45.	12702.	1504141.
2	4.	21.	368.	31.	8697.	1022447.
3	3.	16.	298.	25.	7054.	828232.
4	3.	14.	250.	21.	5914.	693734.
5	3.	13.	217.	18.	5158.	604185.
6	2.	12.	194.	16.	4613.	539923.
7	2.	11.	176.	15.	4190.	490246.
8	2.	10.	162.	13.	3847.	449927.
9	2.	9.	147.	12.	3501.	409616.
10	2.	8.	131.	11.	3118.	365084.
11	1.	7.	116.	10.	2751.	322302.
12	1.	6.	103.	9.	2438.	285557.
13	1.	5.	92.	8.	2179.	255208.
14	1.	5.	83.	7.	1958.	229231.
15	1.	4.	75.	6.	1777.	207971.
16	1.	4.	69.	6.	1633.	191078.
17	1.	4.	64.	5.	1515.	177259.
18	1.	4.	60.	5.	1417.	165729.
19	1.	3.	55.	5.	1309.	153220.

TABLE

***************** NBTC SIMULATION MODEL *****************

...... DAIRY MODEL ... ACCELERATED PROGRAM #2 ....

**************** R E G I O N 8 T O T A L S*************

YR	UND. INF.HRDS	GUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	4.	17.	432.	36.	10343.	1417862.
1	5.	21.	763.	64.	17799.	2503442.
2	6.	26.	695.	58.	16485.	2281511.
3	6.	27.	856.	71.	20184.	2811894.
4	6.	29.	966.	81.	22701.	3171681.
5	6.	30.	1017.	85.	23905.	3339119.
6	7.	31.	1071.	89.	25166.	3517619.
7	7.	32.	1113.	93.	26136.	3655232.
8	7.	32.	1142.	95.	26799.	3749047.
9	7.	33.	1163.	97.	27292.	3818973.
10	7.	33.	1178.	98.	27624.	3866243.
11	7.	33.	1186.	99.	27817.	3893910.
12	7.	33.	1190.	99.	27916.	3908043.
13	7.	33.	1192.	99.	27951.	3913309.
14	7.	33.	1192.	99.	27943.	3912335.
15	7.	33.	1190.	99.	27910.	3907755.
16	7.	33.	1188.	99.	27862.	3901033.
17	7.	33.	1186.	99.	27808.	3893490.
18	7.	33.	1183.	99.	27752.	3885677.
19	7.	33.	1181.	98.	27690.	3877015.

Corresponding projections for dairy herds are itemized in Table 20-D-1. Reductions in all relevant variables were consistently and strongly downward. However, because the initial level of infection for dairy herds was lower than for beef, and because surveillance under the base program was much better for dairy than for beef, the reductions were predictably less spectacular for dairy than for beef. The total number of infected dairy cows (Column 4 plus Column 5) declined from 18,200 to 3,600, while milk losses declined from 38.1 million pounds to 8.6 million pounds.

Examination of regional data shows that infection was reduced in all regions for both beef and dairy herds, not just in those regions where the accelerated program was placed in effect. This occurs because the total interregional infection spread was reduced in all regions when infection levels were reduced in high prevalence regions. Heavy reductions were generally experienced for both beef and dairy herds in the high prevalence regions, although in Region 5 the relative infection reduction in dairy herds was somewhat less than for beef herds.

It might be instructive to project what would happen if, after area testing was completed in each region, all parties (producers, market operators, veterinarians, operating staff in the state and federal brucellosis programs, etc.) relaxed in their vigilance and cooperation so that the level of quality control dropped back to its pre-area testing level. The results of modeling this option are shown in Tables 20-B-2 and 20-D-2. Note that for both beef and dairy, the level of losses remain the same as shown above in Tables 20-B-1 and 20-D-1 through year 9. For subsequent years, however, losses continue to decline at the more rapid rate <u>only if the level of program performance is maintained at a high level</u>. In fact, for beef, the annual losses decline very little in Table 20-B-2 after area testing was completed, due solely to the assumption that the quality control factor was dropped back to the level prevailing before area testing was initiated. The difference in the accumulated losses between these two options was over 79 million pounds of beef.

3. <u>Calfhood Vaccination Program</u>

Under program alternative 3, emphasizing calfhood vaccination, a calfhood vaccination program was imposed <u>on top of</u> the base program in Regions 3, 4, 5, 6, and 7. The detailed infection losses associated with this program option are itemized in the Table 21 series below. Three levels of herd vaccination were modeled: low level (20-59 percent), medium level (60-89 percent) and high level (90 percent and over). In each model calfhood vaccination began in year 1, with 60 percent of the heifer calf crop being vaccinated in each model. This level of vaccination continued each year until the above specified level of vaccination was attained for each model.[2] Eight years' continuous vaccinating of herd replacements were required, for example, to bring the herd vaccination level to 90 percent.

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[2] The percentages of herd vaccination representing the low, medium and high levels in the model were: 39.5 percent, 74.5 percent and 90 percent, respectively.

TABLE 21-B-1

**************** NBTC SIMULATION MODEL ****************

...... BEEF MODEL ... CALFHOOD VACCINATION 39.5%........

**************** U. S. T O T A L S**********************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	20465.	15014.	452329.	111862.	80253744.
1	19997.	15824.	353119.	100511.	65357504.
2	20106.	14909.	337725.	101898.	64184336.
3	22590.	10707.	192075.	78349.	37612160.
4	22894.	9271.	183060.	84785.	36944800.
5	22359.	10420.	212776.	83209.	40160288.
6	23159.	9095.	187844.	87260.	37658368.
7	23843.	9351.	197559.	91006.	39496240.
8	21987.	12286.	246946.	81285.	44210272.
9	20057.	12001.	225394.	72330.	40064448.
10	19283.	9893.	188561.	68092.	34729056.
11	18922.	8733.	170170.	66902.	32205072.
12	18037.	8973.	172435.	63123.	31852288.
13	16659.	9125.	169068.	57778.	30562240.
14	16050.	7863.	147393.	55193.	27420048.
15	15263.	7572.	142991.	52209.	26381168.
16	14373.	7361.	136400.	49006.	25030608.
17	13629.	6855.	127367.	46296.	23455856.
18	12075.	7315.	128420.	41042.	22713200.
19	11457.	5902.	106279.	38510.	19519008.

**************** R E G I O N 1 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	148.	150.	2593.	570.	457179.
1	150.	150.	2022.	565.	383536.
2	146.	146.	2027.	562.	385171.
3	145.	141.	2072.	570.	392217.
4	151.	122.	1863.	605.	369654.
5	152.	131.	2063.	611.	397550.
6	162.	123.	1945.	657.	390395.
7	172.	129.	2096.	700.	419139.
8	153.	165.	2615.	618.	474291.
9	127.	165.	2445.	506.	430440.
10	122.	127.	1848.	483.	344781.
11	119.	113.	1707.	472.	323019.
12	111.	114.	1735.	440.	320419.
13	95.	116.	1718.	377.	306429.
14	91.	96.	1399.	359.	259619.
15	86.	90.	1332.	341.	246974.
16	78.	88.	1303.	309.	237066.
17	73.	80.	1176.	288.	215814.
18	55.	87.	1270.	212.	213369.
19	53.	62.	847.	203.	154994.

TABLE 21-B-1 (continued)

***************** NBTC SIMULATION MODEL *****************

...... BEEF MODEL ... CALFHOOD VACCINATION 39.5%........

**************** R E G I O N 2 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	38.	27.	324.	97.	61575.
1	43.	37.	430.	122.	81732.
2	45.	42.	540.	136.	99481.
3	48.	45.	594.	148.	109226.
4	53.	41.	558.	167.	107763.
5	55.	46.	653.	175.	121944.
6	61.	44.	632.	196.	123075.
7	66.	48.	702.	216.	136211.
8	61.	63.	896.	191.	157519.
9	54.	63.	819.	163.	141849.
10	53.	51.	652.	160.	118548.
11	53.	46.	612.	164.	113821.
12	52.	49.	649.	157.	117500.
13	47.	51.	654.	141.	115313.
14	46.	44.	560.	138.	101894.
15	44.	42.	553.	133.	99957.
16	41.	42.	543.	123.	96731.
17	39.	39.	499.	117.	89594.
18	32.	42.	523.	94.	88758.
19	30.	32.	396.	90.	70840.

.************ R E G I O N 3 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	5092.	3462.	79878.	20316.	14331217.
1	5109.	3916.	63779.	19535.	12083454.
2	5184.	3925.	63069.	20005.	12132590.
3	6043.	2682.	31438.	16295.	6720465.
4	6191.	2380.	31810.	17687.	6889035.
5	6199.	2604.	37296.	17917.	7532802.
6	6462.	2413.	33518.	18999.	7246338.
7	6700.	2471.	36269.	20010.	7753851.
8	6309.	3221.	47343.	17980.	8801151.
9	5870.	3272.	42193.	16151.	7863299.
10	5823.	2651.	33682.	16021.	6776295.
11	5776.	2452.	32657.	15966.	6631712.
12	5645.	2483.	33024.	15609.	6611174.
13	5262.	2681.	34983.	14250.	6628489.
14	5182.	2282.	28686.	14065.	5818921.
15	4964.	2280.	29980.	13309.	5850476.
16	4714.	2247.	28508.	12479.	5534916.
17	4505.	2104.	26446.	11821.	5171412.
18	4029.	2266.	27155.	10487.	5042426.
19	3854.	1844.	22138.	9968.	4332874.

TABLE 21-B-1 (continued)

**************** NBTC SIMULATION MODEL ****************

...... BEEF MODEL ... CALFHOOD VACCINATION 39.5%........

**************** R E G I O N 4 T O T A L S************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	1149.	587.	31204.	8718.	5658272.
1	1133.	609.	24849.	7727.	4649237.
2	1125.	602.	24655.	7727.	4680253.
3	1215.	436.	15123.	5686.	2830505.
4	1201.	389.	15363.	5895.	2861108.
5	1180.	399.	16157.	5893.	2940743.
6	1189.	365.	15557.	5956.	2876539.
7	1197.	365.	15815.	6029.	2921542.
8	1142.	432.	17142.	5745.	3044536.
9	1069.	442.	16647.	5316.	2914346.
10	1043.	373.	14770.	5102.	2645840.
11	1026.	347.	14012.	4987.	2534300.
12	996.	351.	13909.	4834.	2497432.
13	942.	367.	13847.	4556.	2445754.
14	919.	322.	12638.	4411.	2271140.
15	892.	314.	12288.	4271.	2206525.
16	856.	315.	12051.	4096.	2148921.
17	826.	299.	11491.	3939.	2054242.
18	756.	328.	11602.	3610.	2017685.
19	726.	272.	10239.	3430.	1817723.

**************** R E G I O N 5 T O T A L S************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	12872.	9396.	299015.	76189.	53320768.
1	12460.	9539.	234687.	67333.	43430528.
2	12584.	8675.	219963.	68379.	42141136.
3	13946.	6233.	127127.	51505.	24781424.
4	14086.	5328.	118026.	55857.	23913408.
5	13579.	6163.	138959.	54008.	26082448.
6	14023.	5146.	119716.	56444.	24015072.
7	14389.	5297.	124854.	58713.	25030688.
8	13186.	7065.	156383.	52351.	28061440.
9	11969.	6768.	144008.	46552.	25597456.
10	11337.	5645.	122084.	42993.	22259968.
11	11045.	4899.	107894.	41918.	20289488.
12	10408.	5068.	108780.	39016.	19921952.
13	9585.	5009.	104378.	35775.	18861328.
14	9122.	4344.	92614.	33701.	17045168.
15	8629.	4128.	87956.	31791.	16159747.
16	8091.	3977.	83591.	29837.	15293344.
17	7633.	3694.	78224.	28119.	14342829.
18	6736.	3946.	78438.	24931.	13838304.
19	6356.	3152.	65008.	23229.	11877501.

TABLE 21-B-1 (continued)

***************** NBTC SIMULATION MODEL *****************

•••••• BEEF MODEL ••• CALFHOOD VACCINATION 39.5%••••••••

***************** R E G I O N 6 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	735.	1050.	27961.	4003.	4527851.
1	721.	1149.	19842.	3643.	3416040.
2	682.	1124.	20303.	3602.	3490787.
3	841.	862.	11300.	3044.	2015079.
4	873.	756.	11209.	3403.	2054141.
5	867.	825.	12995.	3421.	2280401.
6	938.	761.	11834.	3807.	2200182.
7	997.	796.	13039.	4119.	2405865.
8	854.	1051.	17059.	3355.	2780569.
9	726.	1007.	14484.	2772.	2348232.
10	679.	814.	11688.	2525.	1949155.
11	688.	674.	9804.	2629.	1730867.
12	626.	714.	11000.	2352.	1829443.
13	552.	707.	10226.	2057.	1676517.
14	523.	608.	8722.	1926.	1462489.
15	491.	565.	8248.	1806.	1380626.
16	452.	542.	7834.	1663.	1301470.
17	423.	501.	7199.	1556.	1201385.
18	356.	507.	7172.	1322.	1153918.
19	335.	424.	5819.	1233.	966461.

***************** R E G I O N 7 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	407.	323.	10910.	1900.	1823039.
1	358.	400.	7100.	1510.	1242884.
2	319.	369.	6676.	1410.	1172652.
3	330.	281.	3889.	1022.	675171.
4	319.	229.	3718.	1088.	663286.
5	307.	226.	4092.	1102.	711596.
6	302.	219.	4101.	1114.	715617.
7	299.	218.	4209.	1128.	732327.
8	260.	258.	4858.	966.	786662.
9	225.	254.	4222.	808.	677524.
10	210.	208.	3376.	747.	559475.
11	198.	181.	3054.	703.	510628.
12	185.	172.	2904.	656.	483544.
13	163.	172.	2843.	571.	461397.
14	154.	149.	2421.	543.	402865.
15	144.	136.	2290.	511.	380605.
16	129.	134.	2235.	455.	363948.
17	118.	124.	2027.	414.	330760.
18	100.	122.	1955.	353.	310438.
19	93.	103.	1588.	325.	259046.

TABLE 21-B-1 (continued)

**************** NBTC SIMULATION MODEL ****************

...... BEEF MODEL ... CALFHOOD VACCINATION 39.5%........

**************** R E G I O N 8 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	24.	20.	446.	69.	73887.
1	23.	25.	409.	74.	70118.
2	22.	27.	493.	78.	82300.
3	21.	27.	532.	79.	88107.
4	21.	25.	514.	83.	86445.
5	21.	26.	562.	82.	92840.
6	22.	26.	541.	88.	91172.
7	22.	26.	575.	92.	96654.
8	20.	30.	650.	79.	104133.
9	17.	30.	578.	64.	91338.
10	17.	24.	460.	62.	75018.
11	16.	22.	432.	62.	71255.
12	16.	22.	435.	58.	70850.
13	14.	22.	419.	50.	67026.
14	13.	19.	354.	49.	57975.
15	13.	18.	344.	48.	56298.
16	12.	17.	335.	44.	54243.
17	12.	16.	306.	41.	49846.
18	10.	17.	306.	34.	48342.
19	9.	14.	243.	33.	39604.

TABLE 21-D-1

**************** NBTC SIMULATION MODEL ****************

...... DAIRY MODEL ... CALFHOOD VACCINATION 39.5%........

**************** U. S. T O T A L S**********************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	209.	835.	16800.	1400.	403522.	38057984.
1	165.	815.	15423.	1285.	363686.	35278160.
2	153.	773.	12622.	1052.	299638.	28752864.
3	142.	682.	8196.	683.	184823.	18292416.
4	108.	535.	7062.	589.	159130.	16033705.
5	100.	481.	6155.	513.	139037.	14183853.
6	96.	458.	5662.	472.	128397.	13199320.
7	97.	454.	5494.	458.	124789.	12883181.
8	99.	461.	5478.	456.	124566.	12877837.
9	96.	450.	5422.	452.	123297.	12780788.
10	89.	423.	5245.	437.	119216.	12417650.
11	84.	399.	5030.	419.	114322.	11967289.
12	81.	384.	4856.	405.	110435.	11603901.
13	78.	369.	4707.	392.	107088.	11291063.
14	74.	349.	4532.	378.	103105.	10919962.
15	70.	332.	4358.	363.	99166.	10550266.
16	67.	317.	4199.	350.	95570.	10211513.
17	63.	301.	4044.	337.	92080.	9883382.
18	60.	286.	3894.	324.	88675.	9563013.
19	56.	266.	3709.	309.	84460.	9166956.

**************** R E G I O N 1 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	26.	103.	1605.	134.	38659.	4047638.
1	18.	86.	1288.	107.	30618.	3246943.
2	15.	72.	1043.	87.	24903.	2630215.
3	14.	64.	911.	76.	21773.	2296362.
4	12.	57.	799.	67.	19107.	2015221.
5	11.	53.	726.	60.	17375.	1830567.
6	11.	51.	683.	57.	16370.	1722642.
7	11.	51.	669.	56.	16058.	1688019.
8	11.	52.	678.	56.	16269.	1708769.
9	11.	51.	670.	56.	16072.	1689068.
10	10.	46.	628.	52.	15054.	1584479.
11	9.	43.	581.	48.	13921.	1465824.
12	9.	40.	546.	45.	13075.	1376011.
13	8.	38.	516.	43.	12362.	1300699.
14	8.	35.	479.	40.	11465.	1207054.
15	7.	33.	444.	37.	10634.	1119571.
16	7.	31.	415.	35.	9938.	1046067.
17	6.	29.	387.	32.	9271.	975933.
18	6.	27.	361.	30.	8638.	909320.
19	5.	23.	324.	27.	7759.	817645.

TABLE 21-D-1 (continued)

***************** NBTC SIMULATION MODEL *****************

...... DAIRY MODEL ... CALFHOOD VACCINATION 39.5%........

**************** R E G I O N 2 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	2.	10.	61.	5.	1474.	147641.
1	1.	6.	58.	5.	1393.	141481.
2	1.	5.	53.	4.	1273.	129709.
3	1.	5.	49.	4.	1161.	118219.
4	1.	4.	44.	4.	1053.	107230.
5	1.	4.	41.	3.	983.	99963.
6	1.	5.	40.	3.	947.	96182.
7	1.	5.	40.	3.	951.	96442.
8	1.	5.	41.	3.	984.	99685.
9	1.	5.	41.	3.	992.	100545.
10	1.	5.	40.	3.	956.	97012.
11	1.	4.	38.	3.	914.	92764.
12	1.	4.	37.	3.	885.	89828.
13	1.	4.	36.	3.	861.	87320.
14	1.	4.	34.	3.	821.	83332.
15	1.	4.	33.	3.	784.	79558.
16	1.	4.	31.	3.	750.	76149.
17	1.	4.	30.	2.	714.	72515.
18	1.	3.	28.	2.	678.	68808.
19	1.	3.	26.	2.	620.	63030.

**************** R E G I O N 3 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	79.	314.	5207.	434.	125173.	10443844.
1	46.	240.	3957.	330.	93406.	7933941.
2	38.	192.	2978.	248.	70720.	5971107.
3	33.	158.	1666.	139.	37049.	3141852.
4	24.	117.	1309.	109.	29025.	2469430.
5	22.	103.	1066.	89.	23661.	2009858.
6	21.	98.	952.	79.	21204.	1794484.
7	21.	98.	916.	76.	20435.	1726896.
8	22.	99.	914.	76.	20412.	1723398.
9	21.	98.	907.	76.	20236.	1708972.
10	20.	93.	878.	73.	19585.	1655190.
11	20.	90.	846.	70.	18862.	1594234.
12	19.	88.	821.	68.	18324.	1548272.
13	19.	86.	802.	67.	17895.	1511805.
14	18.	82.	774.	64.	17264.	1459061.
15	17.	80.	745.	62.	16629.	1405448.
16	17.	76.	717.	60.	16001.	1352325.
17	16.	73.	688.	57.	15338.	1296497.
18	15.	70.	657.	55.	14655.	1238849.
19	14.	65.	618.	52.	13786.	1165844.

TABLE 21-D-1 (continued)

***************** NBTC SIMULATION MODEL *****************

...... DAIRY MODEL ... CALFHOOD VACCINATION 39.5%........

**************** R E G I O N 4 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	19.	77.	5341.	445.	127983.	12591584.
1	10.	71.	4966.	414.	115681.	11701157.
2	7.	71.	3203.	267.	74809.	7545854.
3	6.	51.	1554.	130.	34171.	3446292.
4	4.	39.	1233.	103.	27084.	2733627.
5	4.	32.	991.	83.	21769.	2197171.
6	4.	28.	839.	70.	18481.	1858954.
7	4.	26.	772.	64.	17052.	1712412.
8	4.	25.	743.	62.	16422.	1647517.
9	3.	25.	727.	61.	16063.	1611153.
10	3.	24.	706.	59.	15605.	1565974.
11	3.	23.	681.	57.	15034.	1508944.
12	3.	22.	657.	55.	14508.	1455905.
13	3.	22.	637.	53.	14075.	1412233.
14	3.	21.	617.	51.	13624.	1367159.
15	3.	20.	595.	50.	13144.	1319168.
16	3.	20.	574.	48.	12687.	1273140.
17	3.	19.	555.	46.	12250.	1229358.
18	3.	18.	535.	45.	11811.	1185335.
19	2.	17.	511.	43.	11276.	1132075.

**************** R E G I O N 5 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	51.	205.	2840.	237.	68287.	6042082.
1	64.	292.	3277.	273.	78322.	6968174.
2	67.	317.	3672.	306.	88069.	7809532.
3	65.	299.	2571.	214.	57362.	5142700.
4	48.	232.	2254.	188.	50018.	4507989.
5	45.	209.	1950.	162.	43274.	3900334.
6	43.	199.	1768.	147.	39336.	3535978.
7	43.	196.	1695.	141.	37742.	3389229.
8	43.	199.	1676.	140.	37364.	3352303.
9	42.	193.	1643.	137.	36605.	3285279.
10	39.	180.	1565.	130.	34853.	3130977.
11	36.	168.	1471.	123.	32728.	2941091.
12	34.	160.	1392.	116.	30979.	2783044.
13	33.	152.	1322.	110.	29436.	2644143.
14	31.	142.	1247.	104.	27768.	2494929.
15	29.	134.	1173.	98.	26118.	2346943.
16	27.	126.	1106.	92.	24621.	2212136.
17	26.	119.	1043.	87.	23215.	2085818.
18	24.	112.	983.	82.	21880.	1965953.
19	22.	103.	914.	76.	20348.	1828983.

TABLE 21-D-1 (continued)

**************** NBTC SIMULATION MODEL ****************

...... DAIRY MODEL ... CALFHOOD VACCINATION 39.5%........

**************** R E G I O N 6 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	14.	55.	524.	44.	12625.	1170281.
1	15.	69.	573.	48.	13766.	1278924.
2	15.	69.	610.	51.	14682.	1362526.
3	14.	63.	396.	33.	8857.	830840.
4	10.	47.	319.	27.	7101.	669280.
5	9.	42.	268.	22.	5970.	561994.
6	9.	40.	243.	20.	5431.	509734.
7	9.	40.	238.	20.	5324.	498990.
8	9.	42.	242.	20.	5435.	508881.
9	9.	40.	237.	20.	5308.	497440.
10	8.	37.	220.	18.	4927.	462389.
11	7.	33.	202.	17.	4509.	423250.
12	7.	32.	190.	16.	4244.	398099.
13	7.	30.	179.	15.	4009.	376019.
14	6.	28.	167.	14.	3731.	350085.
15	6.	26.	155.	13.	3467.	325352.
16	5.	24.	145.	12.	3241.	304054.
17	5.	22.	135.	11.	3031.	284392.
18	5.	21.	127.	11.	2837.	266172.
19	4.	19.	116.	10.	2599.	243979.

**************** R E G I O N 7 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	14.	54.	791.	66.	18977.	2197087.
1	6.	30.	541.	45.	12702.	1504141.
2	4.	21.	368.	31.	8697.	1022447.
3	3.	15.	193.	16.	4265.	504265.
4	2.	10.	142.	12.	3129.	371186.
5	2.	8.	105.	9.	2325.	275441.
6	2.	8.	85.	7.	1892.	223184.
7	2.	7.	76.	6.	1678.	197538.
8	2.	7.	70.	6.	1565.	183901.
9	1.	6.	66.	5.	1461.	171738.
10	1.	6.	60.	5.	1341.	157796.
11	1.	5.	55.	5.	1231.	144808.
12	1.	5.	51.	4.	1141.	134146.
13	1.	5.	48.	4.	1064.	125138.
14	1.	4.	44.	4.	984.	115730.
15	1.	4.	41.	3.	912.	107323.
16	1.	4.	38.	3.	851.	100093.
17	1.	3.	36.	3.	791.	93012.
18	1.	3.	33.	3.	733.	86204.
19	1.	3.	30.	3.	670.	78860.

TABLE 21-D-1 (continued)

**************** NBTC SIMULATION MODEL ****************

...... DAIRY MODEL ... CALFHOOD VACCINATION 39.5%........

**************** R E G I O N 8 T O T A L S************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	4.	17.	432.	36.	10343.	1417862.
1	5.	21.	763.	64.	17799.	2503442.
2	6.	26.	695.	58.	16485.	2281511.
3	6.	27.	856.	71.	20184.	2811895.
4	6.	29.	962.	80.	22612.	3159744.
5	6.	30.	1008.	84.	23679.	3308526.
6	6.	31.	1053.	88.	24735.	3458163.
7	7.	31.	1088.	91.	25549.	3573656.
8	7.	32.	1113.	93.	26115.	3653385.
9	7.	32.	1132.	94.	26561.	3716594.
10	7.	32.	1146.	96.	26894.	3763835.
11	7.	32.	1156.	96.	27123.	3796376.
12	7.	32.	1163.	97.	27280.	3818599.
13	7.	32.	1168.	97.	27386.	3833707.
14	7.	33.	1170.	98.	27448.	3842615.
15	7.	33.	1172.	98.	27478.	3846904.
16	7.	32.	1172.	98.	27482.	3847550.
17	7.	32.	1171.	98.	27469.	3845858.
18	7.	32.	1170.	98.	27444.	3842375.
19	7.	32.	1169.	97.	27402.	3836541.

TABLE 21-B-2.

***************** NBTC SIMULATION MODEL *****************

...... BEEF MODEL ... CALFHOOD VACCINATION 74.5%........

***************** U. S. T O T A L S**********************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	20465.	15014.	452329.	111862.	80253744.
1	19997.	15824.	353119.	100511.	65357504.
2	20106.	14909.	337725.	101898.	64184336.
3	22590.	10707.	192075.	78349.	37612160.
4	25016.	6408.	98340.	63276.	22706672.
5	26457.	4058.	62540.	50077.	14700905.
6	26348.	4308.	68778.	53646.	15565944.
7	26392.	4413.	73365.	54814.	16132204.
8	25271.	5649.	86347.	51264.	17227536.
9	23387.	6055.	87204.	45052.	16510023.
10	22696.	4355.	65050.	43567.	13626314.
11	22253.	4075.	59725.	43022.	12907949.
12	21538.	4277.	62095.	41589.	12992301.
13	20133.	4826.	67374.	37560.	13103189.
14	19561.	3633.	52902.	36686.	11236472.
15	18932.	3688.	51942.	35615.	10964720.
16	18165.	3705.	51583.	34103.	10720864.
17	17485.	3480.	48943.	32779.	10228646.
18	15939.	4254.	55295.	28789.	10467932.
19	15144.	3114.	43164.	26963.	8778018.

***************** R E G I O N 1 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	148.	150.	2593.	570.	457179.
1	150.	150.	2022.	565.	383536.
2	146.	146.	2027.	562.	385171.
3	145.	141.	2072.	570.	392217.
4	151.	122.	1863.	605.	369654.
5	146.	127.	2002.	589.	384338.
6	148.	113.	1787.	600.	356174.
7	150.	112.	1814.	611.	361667.
8	129.	138.	2161.	517.	391725.
9	104.	135.	1972.	412.	347178.
10	97.	101.	1458.	384.	272023.
11	93.	88.	1330.	371.	251717.
12	86.	88.	1337.	340.	246787.
13	73.	89.	1318.	289.	234836.
14	69.	73.	1065.	273.	197440.
15	65.	68.	1013.	258.	187476.
16	59.	67.	994.	235.	180592.
17	56.	61.	904.	220.	165702.
18	42.	67.	986.	163.	165356.
19	40.	48.	661.	157.	120659.

TABLE 21-B-2 (Continued).

***************** NBTC SIMULATION MODEL *****************

...... BEEF MODEL ... CALFHOOD VACCINATION 74.5%........

**************** R E G I O N 2 T O T A L S************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	38.	27.	324.	97.	61575.
1	43.	37.	430.	122.	81732.
2	45.	42.	540.	136.	99481.
3	48.	45.	594.	148.	109226.
4	53.	41.	558.	167.	107763.
5	53.	44.	624.	167.	116104.
6	55.	40.	558.	175.	108329.
7	57.	40.	580.	183.	112698.
8	51.	51.	707.	156.	124699.
9	44.	50.	632.	130.	109924.
10	42.	39.	493.	124.	89818.
11	41.	35.	453.	124.	84443.
12	39.	36.	471.	116.	85496.
13	34.	36.	468.	103.	82600.
14	33.	31.	395.	99.	71838.
15	31.	29.	385.	93.	69520.
16	29.	29.	375.	86.	66848.
17	27.	27.	345.	81.	61818.
18	22.	29.	362.	65.	61268.
19	21.	22.	273.	62.	48632.

**************** R E G I O N 3 T O T A L S************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	5092.	3462.	79878.	20316.	14331217.
1	5109.	3916.	63779.	19535.	12083454.
2	5184.	3925.	63069.	20005.	12132590.
3	6043.	2682.	31438.	16295.	6720465.
4	6768.	1611.	14999.	13454.	4053659.
5	7199.	1008.	9014.	10755.	2581462.
6	7205.	1040.	10303.	11543.	2750728.
7	7244.	1080.	11096.	11859.	2854654.
8	7014.	1373.	13392.	11246.	3058393.
9	6580.	1524.	14609.	10039.	3053256.
10	6432.	1141.	10341.	9860.	2512790.
11	6334.	1045.	9741.	9791.	2429776.
12	6176.	1090.	10225.	9551.	2456340.
13	5844.	1240.	11706.	8716.	2529856.
14	5709.	978.	8822.	8592.	2164589.
15	5557.	965.	8802.	8396.	2135723.
16	5370.	979.	8904.	8103.	2109697.
17	5198.	934.	8558.	7821.	2032452.
18	4777.	1158.	10496.	6806.	2134945.
19	4580.	861.	7389.	6475.	1724142.

TABLE 21-B-2 (Continued).

**************** NBTC SIMULATION MODEL ****************

...... BEEF MODEL ... CALFHOOD VACCINATION 74.5%........

**************** R E G I O N 4 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	1149.	587.	31204.	8718.	5658272.
1	1133.	609.	24849.	7727.	4649237.
2	1125.	602.	24655.	7727.	4680253.
3	1215.	436.	15123.	5686.	2830505.
4	1282.	278.	8925.	4237.	1787258.
5	1303.	180.	5951.	3119.	1146543.
6	1267.	178.	6307.	3217.	1184910.
7	1238.	173.	6441.	3193.	1190775.
8	1174.	206.	6841.	2983.	1212511.
9	1097.	205.	6556.	2713.	1142170.
10	1053.	161.	5654.	2550.	1012905.
11	1017.	150.	5263.	2450.	953735.
12	976.	152.	5159.	2340.	926759.
13	922.	159.	5085.	2184.	897217.
14	886.	131.	4556.	2081.	820069.
15	850.	131.	4378.	1990.	787397.
16	811.	129.	4246.	1888.	757860.
17	775.	120.	4005.	1794.	716672.
18	719.	138.	4013.	1639.	696976.
19	686.	104.	3470.	1544.	619155.

**************** R E G I O N 5 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	12872.	9396.	299015.	76189.	53320768.
1	12460.	9539.	234687.	67333.	43430528.
2	12584.	8675.	219963.	68379.	42141136.
3	13946.	6233.	127127.	51505.	24781424.
4	15340.	3614.	63886.	41055.	14663186.
5	16176.	2215.	39163.	32202.	9234131.
6	16077.	2411.	43007.	34544.	9776484.
7	16070.	2457.	46183.	35266.	10158023.
8	15350.	3201.	54773.	32918.	10875850.
9	14169.	3402.	54666.	28841.	10338246.
10	13716.	2362.	40816.	27776.	8527883.
11	13432.	2262.	36915.	27418.	8012131.
12	12968.	2395.	38693.	26461.	8091939.
13	12080.	2726.	42010.	23836.	8156795.
14	11714.	1965.	32895.	23231.	6979999.
15	11316.	2058.	32165.	22526.	6789044.
16	10839.	2054.	31823.	21564.	6624754.
17	10416.	1917.	30260.	20729.	6329793.
18	9494.	2373.	33915.	18345.	6464354.
19	8968.	1719.	27503.	17001.	5527455.

TABLE 21-B-2 (Continued).

**************** NBTC SIMULATION MODEL ****************

...... BEEF MODEL ... CALFHOOD VACCINATION 74.5%........

**************** R E G I O N 6 T O T A L S************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	735.	1050.	27961.	4003.	4527851.
1	721.	1149.	19842.	3643.	3416040.
2	682.	1124.	20303.	3602.	3490787.
3	841.	862.	11300.	3044.	2015079.
4	1049.	535.	5490.	2850.	1225562.
5	1196.	343.	3776.	2497.	864828.
6	1225.	385.	4607.	2777.	989770.
7	1267.	409.	4973.	2909.	1046885.
8	1213.	519.	5975.	2718.	1140023.
9	1087.	572.	6339.	2294.	1120337.
10	1065.	415.	4385.	2280.	881823.
11	1056.	376.	4242.	2292.	864326.
12	1027.	396.	4420.	2229.	875920.
13	933.	452.	4996.	1930.	900931.
14	914.	346.	3646.	1929.	737719.
15	888.	336.	3718.	1889.	738767.
16	847.	346.	3753.	1796.	728899.
17	814.	326.	3530.	1723.	691029.
18	708.	386.	4087.	1424.	712260.
19	681.	277.	2751.	1395.	547352.

**************** R E G I O N 7 T O T A L S************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	407.	323.	10910.	1900.	1823039.
1	358.	400.	7100.	1510.	1242884.
2	319.	369.	6676.	1410.	1172652.
3	330.	281.	3889.	1022.	675171.
4	352.	183.	2106.	825.	413173.
5	364.	115.	1462.	670.	283544.
6	351.	118.	1709.	713.	316144.
7	345.	119.	1773.	714.	323009.
8	324.	136.	1945.	659.	335893.
9	291.	144.	1938.	569.	321242.
10	277.	116.	1507.	540.	264808.
11	266.	100.	1404.	524.	250073.
12	254.	101.	1405.	502.	246799.
13	235.	105.	1414.	460.	241000.
14	224.	92.	1201.	438.	212223.
15	213.	85.	1163.	421.	205067.
16	200.	86.	1173.	392.	201566.
17	190.	80.	1048.	373.	183832.
18	168.	88.	1139.	316.	186010.
19	159.	72.	876.	299.	151676.

TABLE 21-B-2 (Continued).

**************** NBTC SIMULATION MODEL ****************

...... BEEF MODEL ... CALFHOOD VACCINATION 74.5%........

*************** R E G I O N 8 T O T A L S************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	24.	20.	446.	69.	73887.
1	23.	25.	409.	74.	70118.
2	22.	27.	493.	78.	82300.
3	21.	27.	532.	79.	88107.
4	21.	25.	514.	83.	86445.
5	20.	26.	547.	79.	89958.
6	20.	23.	499.	78.	83407.
7	20.	23.	506.	79.	84494.
8	17.	25.	554.	66.	88448.
9	15.	25.	492.	54.	77673.
10	14.	20.	396.	52.	64267.
11	14.	18.	376.	53.	61750.
12	13.	18.	385.	50.	62263.
13	12.	19.	377.	44.	59958.
14	12.	16.	323.	43.	52597.
15	11.	16.	318.	42.	51730.
16	11.	16.	315.	39.	50651.
17	10.	15.	293.	38.	47349.
18	9.	15.	298.	31.	46763.
19	9.	13.	242.	30.	38949.

TABLE 21-D-2.

**************** NBTC SIMULATION MODEL ****************

•••••• DAIRY MODEL ••• CALFHOOD VACCINATION 74.5%••••••••

**************** U. S. T O T A L S**********************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	209.	835.	16800.	1400.	403522.	38057984.
1	165.	815.	15423.	1285.	363686.	35278160.
2	153.	773.	12622.	1052.	299638.	28752864.
3	142.	682.	8196.	683.	184823.	18292416.
4	106.	504.	5247.	437.	118930.	12322423.
5	78.	310.	3438.	286.	76499.	8449593.
6	58.	247.	2865.	239.	64448.	7352302.
7	53.	227.	2549.	212.	57876.	6747500.
8	52.	218.	2420.	202.	55252.	6506274.
9	50.	210.	2351.	196.	53762.	6372852.
10	47.	196.	2265.	189.	51793.	6187331.
11	44.	186.	2183.	182.	49943.	6008055.
12	43.	180.	2125.	177.	48624.	5878707.
13	42.	175.	2079.	173.	47590.	5777487.
14	40.	166.	2024.	169.	46336.	5654966.
15	38.	159.	1973.	164.	45163.	5539358.
16	37.	154.	1930.	161.	44201.	5443718.
17	36.	149.	1891.	158.	43314.	5355737.
18	34.	143.	1853.	154.	42476.	5272665.
19	32.	135.	1802.	150.	41304.	5156801.

**************** R E G I O N 1 T O T A L S************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	26.	103.	1605.	134.	38659.	4047638.
1	18.	86.	1288.	107.	30618.	3246943.
2	15.	72.	1043.	87.	24903.	2630215.
3	14.	64.	911.	76.	21773.	2296362.
4	12.	57.	799.	67.	19107.	2015221.
5	11.	51.	709.	59.	16958.	1787833.
6	10.	47.	637.	53.	15245.	1606162.
7	10.	44.	592.	49.	14185.	1492981.
8	9.	43.	570.	48.	13673.	1437632.
9	9.	41.	539.	45.	12917.	1358883.
10	8.	36.	485.	40.	11615.	1223679.
11	7.	32.	434.	36.	10375.	1093202.
12	6.	30.	396.	33.	9486.	998750.
13	6.	28.	367.	31.	8791.	925297.
14	5.	25.	334.	28.	8005.	842990.
15	5.	23.	305.	25.	7309.	769718.
16	5.	21.	282.	24.	6763.	711909.
17	4.	20.	262.	22.	6274.	660406.
18	4.	18.	244.	20.	5836.	614240.
19	3.	16.	218.	18.	5217.	549649.

TABLE 21-D-2 (Continued).

**************** NBTC SIMULATION MODEL ****************

...... DAIRY MODEL ... CALFHOOD VACCINATION 74.5%........

**************** R E G I O N 2 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	2.	10.	61.	5.	1474.	147641.
1	1.	6.	58.	5.	1393.	141481.
2	1.	5.	53.	4.	1273.	129709.
3	1.	5.	49.	4.	1161.	118219.
4	1.	4.	44.	4.	1053.	107230.
5	1.	4.	40.	3.	963.	97998.
6	1.	4.	37.	3.	888.	90283.
7	1.	4.	35.	3.	846.	85827.
8	1.	4.	35.	3.	831.	84283.
9	1.	4.	34.	3.	801.	81284.
10	1.	4.	31.	3.	741.	75291.
11	1.	3.	29.	2.	683.	69421.
12	1.	3.	27.	2.	642.	65159.
13	1.	3.	25.	2.	608.	61674.
14	1.	3.	24.	2.	565.	57403.
15	1.	3.	22.	2.	528.	53572.
16	1.	3.	21.	2.	496.	50310.
17	1.	2.	19.	2.	464.	47155.
18	0.	2.	18.	2.	435.	44187.
19	0.	2.	16.	1.	393.	39952.

**************** R E G I O N 3 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	79.	314.	5207.	434.	125173.	10443844.
1	46.	240.	3957.	330.	93406.	7933941.
2	38.	192.	2978.	248.	70720.	5971107.
3	33.	158.	1666.	139.	37049.	3141852.
4	23.	109.	857.	71.	18988.	1615977.
5	16.	59.	403.	34.	8386.	720032.
6	11.	43.	269.	22.	5590.	480299.
7	10.	38.	201.	17.	4198.	359113.
8	9.	36.	176.	15.	3687.	313902.
9	9.	35.	166.	14.	3489.	296669.
10	9.	33.	158.	13.	3318.	282163.
11	8.	32.	151.	13.	3171.	269621.
12	8.	31.	146.	12.	3068.	260798.
13	8.	30.	142.	12.	2989.	254027.
14	8.	29.	137.	11.	2885.	245281.
15	7.	28.	132.	11.	2781.	236469.
16	7.	27.	128.	11.	2693.	228921.
17	7.	26.	124.	10.	2610.	221829.
18	7.	26.	120.	10.	2526.	214720.
19	6.	24.	114.	10.	2404.	204414.

TABLE 21-D-2 (Continued).

***************** NBTC SIMULATION MODEL *****************

•••••• DAIRY MODEL ••• CALFHOOD VACCINATION 74.5%••••••••

**************** R E G I O N 4 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	19.	77.	5341.	445.	127983.	12591584.
1	10.	71.	4966.	414.	115681.	11701157.
2	7.	71.	3203.	267.	74809.	7545854.
3	6.	51.	1554.	130.	34171.	3446292.
4	4.	38.	812.	68.	17828.	1799584.
5	3.	26.	404.	34.	8335.	848453.
6	2.	17.	278.	23.	5726.	583763.
7	2.	13.	196.	16.	4044.	411400.
8	2.	11.	155.	13.	3216.	325626.
9	1.	10.	138.	11.	2866.	289603.
10	1.	9.	127.	11.	2650.	267700.
11	1.	8.	119.	10.	2484.	250834.
12	1.	8.	113.	9.	2353.	237520.
13	1.	8.	108.	9.	2247.	226851.
14	1.	7.	103.	9.	2148.	216838.
15	1.	7.	99.	8.	2050.	206989.
16	1.	7.	94.	8.	1959.	197794.
17	1.	6.	90.	8.	1875.	189251.
18	1.	6.	86.	7.	1793.	181036.
19	1.	6.	82.	7.	1705.	172152.

**************** R E G I O N 5 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	51.	205.	2840.	237.	68287.	6042082.
1	64.	292.	3277.	273.	78322.	6968174.
2	67.	317.	3672.	306.	88069.	7809532.
3	65.	299.	2571.	214.	57362.	5142700.
4	47.	215.	1471.	123.	32639.	2942706.
5	33.	113.	735.	61.	15295.	1393447.
6	22.	85.	504.	42.	10465.	954892.
7	20.	77.	377.	31.	7853.	713776.
8	19.	74.	326.	27.	6818.	616779.
9	18.	71.	305.	25.	6389.	577214.
10	17.	66.	286.	24.	6004.	542538.
11	16.	63.	270.	23.	5668.	512079.
12	16.	61.	259.	22.	5435.	490823.
13	15.	59.	251.	21.	5256.	474598.
14	15.	56.	240.	20.	5027.	454035.
15	14.	53.	229.	19.	4797.	433304.
16	13.	52.	220.	18.	4607.	416087.
17	13.	49.	211.	18.	4432.	400274.
18	12.	48.	203.	17.	4260.	384723.
19	12.	44.	192.	16.	4028.	363964.

TABLE 21-D-2 (Continued).

***************** NBTC SIMULATION MODEL *****************

...... DAIRY MODEL ... CALFHOOD VACCINATION 74.5%........

**************** R E G I O N 6 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	14.	55.	524.	44.	12625.	1170281.
1	15.	69.	573.	48.	13766.	1278924.
2	15.	69.	610.	51.	14682.	1362526.
3	14.	63.	396.	33.	8857.	830840.
4	10.	44.	209.	17.	4651.	438444.
5	7.	23.	99.	8.	2075.	197469.
6	5.	17.	67.	6.	1401.	133460.
7	4.	16.	53.	4.	1109.	105119.
8	4.	16.	49.	4.	1023.	96599.
9	4.	16.	47.	4.	987.	93067.
10	4.	14.	44.	4.	925.	87340.
11	4.	14.	41.	3.	873.	82411.
12	4.	13.	40.	3.	843.	79496.
13	4.	13.	39.	3.	821.	77385.
14	3.	12.	37.	3.	778.	73437.
15	3.	12.	35.	3.	741.	69945.
16	3.	11.	34.	3.	713.	67294.
17	3.	11.	33.	3.	686.	64756.
18	3.	10.	31.	3.	659.	62195.
19	3.	9.	29.	2.	611.	57674.

**************** R E G I O N 7 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	14.	54.	791.	66.	18977.	2197087.
1	6.	30.	541.	45.	12702.	1504141.
2	4.	21.	368.	31.	8697.	1022447.
3	3.	15.	193.	16.	4265.	504265.
4	2.	9.	93.	8.	2053.	243520.
5	1.	4.	41.	3.	859.	102727.
6	1.	3.	26.	2.	547.	65407.
7	1.	3.	18.	2.	384.	45721.
8	1.	3.	15.	1.	316.	37417.
9	1.	3.	14.	1.	285.	33722.
10	1.	2.	13.	1.	262.	31001.
11	1.	2.	12.	1.	244.	28850.
12	1.	2.	11.	1.	230.	27224.
13	1.	2.	10.	1.	219.	25913.
14	1.	2.	10.	1.	208.	24570.
15	1.	2.	9.	1.	197.	23324.
16	0.	2.	9.	1.	188.	22204.
17	0.	2.	9.	1.	179.	21126.
18	0.	2.	8.	1.	170.	20122.
19	0.	1.	8.	1.	159.	18862.

TABLE 21-D-2 (Continued).

***************** NBTC SIMULATION MODEL *****************

...... DAIRY MODEL ... CALFHOOD VACCINATION 74.5%........

**************** R E G I O N 8 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	4.	17.	432.	36.	10343.	1417862.
1	5.	21.	763.	64.	17799.	2503442.
2	6.	26.	695.	58.	16485.	2281511.
3	6.	27.	856.	71.	20184.	2811895.
4	6.	29.	962.	80.	22612.	3159744.
5	6.	30.	1006.	84.	23628.	3301636.
6	6.	30.	1047.	87.	24586.	3438038.
7	6.	31.	1076.	90.	25258.	3533565.
8	7.	31.	1095.	91.	25687.	3594037.
9	7.	31.	1109.	92.	26028.	3642414.
10	7.	31.	1120.	93.	26276.	3677620.
11	7.	32.	1127.	94.	26446.	3701640.
12	7.	32.	1133.	94.	26568.	3718938.
13	7.	32.	1137.	95.	26658.	3731744.
14	7.	32.	1139.	95.	26719.	3740413.
15	7.	32.	1141.	95.	26758.	3746039.
16	7.	32.	1142.	95.	26781.	3749202.
17	7.	32.	1142.	95.	26793.	3750940.
18	7.	32.	1143.	95.	26796.	3751444.
19	7.	32.	1142.	95.	26786.	3750137.

TABLE 21-B-3

****************** NBTC SIMULATION MODEL *******************

...... BEEF MODEL ... CALFHOOD VACCINATION 90% ....

****************** U. S. T O T A L S***********************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	20465.	15014.	452329.	111862.	80253744.
1	19997.	15824.	353119.	100511.	65357504.
2	20106.	14909.	337725.	101898.	64184336.
3	22590.	10707.	192075.	78349.	37612160.
4	25016.	6408.	98340.	63276.	22706672.
5	26457.	4058.	62540.	50077.	14700905.
6	27714.	2737.	36017.	39133.	9663471.
7	28390.	1423.	23704.	30059.	6596391.
8	27242.	3573.	31885.	29483.	7319276.
9	25933.	2869.	30704.	27532.	6883867.
10	25138.	2440.	25151.	26451.	6101996.
11	24526.	2671.	22695.	25976.	5760873.
12	23775.	2575.	23623.	25089.	5752839.
13	22774.	2601.	24014.	23761.	5638441.
14	22096.	2107.	21027.	23046.	5200494.
15	21411.	2423.	20494.	22333.	5051665.
16	20648.	2254.	20343.	21473.	4930519.
17	19951.	2084.	19283.	20724.	4716269.
18	18796.	2585.	21337.	19094.	4759883.
19	18097.	1709.	17113.	18403.	4182192.

****************** R E G I O N 1 T O T A L S***************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	148.	150.	2593.	570.	457179.
1	150.	150.	2022.	565.	383536.
2	146.	146.	2027.	562.	385171.
3	145.	141.	2072.	570.	392217.
4	151.	122.	1863.	605.	369654.
5	146.	127.	2002.	589.	384338.
6	148.	113.	1787.	600.	356174.
7	146.	109.	1768.	592.	351056.
8	119.	127.	1990.	476.	359332.
9	92.	119.	1716.	362.	301542.
10	83.	85.	1213.	326.	226799.
11	77.	72.	1073.	305.	203484.
12	69.	70.	1050.	272.	194026.
13	57.	69.	1009.	224.	179933.
14	53.	55.	801.	208.	148712.
15	49.	51.	752.	193.	139230.
16	44.	49.	728.	173.	132273.
17	40.	44.	654.	160.	119814.
18	30.	48.	705.	117.	118362.
19	29.	35.	476.	113.	86773.

TABLE 21-B-3 (continued)

**************** NBTC SIMULATION MODEL ****************

•••••• BEEF MODEL ••• CALFHOOD VACCINATION 90% ••••••••

**************** R E G I O N 2 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	38.	27.	324.	97.	61575.
1	43.	37.	430.	122.	81732.
2	45.	42.	540.	136.	99481.
3	48.	45.	594.	148.	109226.
4	53.	41.	558.	167.	107763.
5	53.	44.	624.	167.	116104.
6	55.	40.	558.	175.	108329.
7	56.	39.	559.	176.	108266.
8	47.	46.	633.	143.	111794.
9	39.	43.	535.	114.	93300.
10	36.	33.	400.	106.	73539.
11	34.	28.	358.	102.	67162.
12	31.	28.	363.	94.	66160.
13	27.	28.	352.	80.	62399.
14	25.	23.	291.	75.	53273.
15	24.	22.	279.	70.	50643.
16	21.	21.	268.	63.	47841.
17	20.	19.	242.	58.	43473.
18	16.	20.	250.	46.	42463.
19	14.	15.	188.	43.	33573.

**************** R E G I O N 3 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	5092.	3462.	79878.	20316.	14331217.
1	5109.	3916.	63779.	19535.	12083454.
2	5184.	3925.	63069.	20005.	12132590.
3	6043.	2682.	31438.	16295.	6720465.
4	6768.	1611.	14999.	13454.	4053659.
5	7199.	1008.	9014.	10755.	2581462.
6	7543.	654.	4543.	8367.	1640094.
7	7716.	317.	2668.	6353.	1073262.
8	7441.	741.	4044.	6301.	1197373.
9	7114.	657.	4191.	5966.	1165600.
10	6911.	540.	3299.	5771.	1041226.
11	6744.	566.	3023.	5652.	995307.
12	6552.	556.	3091.	5493.	984903.
13	6296.	584.	3313.	5233.	981107.
14	6118.	475.	2826.	5094.	908829.
15	5937.	524.	2783.	4950.	887131.
16	5737.	505.	2819.	4770.	870810.
17	5552.	470.	2673.	4611.	835800.
18	5255.	587.	3120.	4279.	849729.
19	5067.	405.	2429.	4122.	752097.

TABLE 21-B-3 (continued)

**************** NBTC SIMULATION MODEL ****************

...... BEEF MODEL ... CALFHOOD VACCINATION 90% ....

**************** R E G I O N 4 T O T A L S************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	1149.	587.	31204.	8718.	5658272.
1	1133.	609.	24849.	7727.	4649237.
2	1125.	602.	24655.	7727.	4680253.
3	1215.	436.	15123.	5686.	2830505.
4	1282.	278.	8925.	4237.	1787258.
5	1303.	180.	5951.	3119.	1146543.
6	1317.	121.	3682.	2282.	746050.
7	1310.	71.	2476.	1679.	496669.
8	1242.	138.	2911.	1626.	533651.
9	1170.	110.	2736.	1478.	492350.
10	1119.	92.	2299.	1378.	430420.
11	1075.	98.	2107.	1313.	400722.
12	1029.	91.	2043.	1246.	385167.
13	976.	90.	1997.	1162.	369758.
14	936.	73.	1784.	1105.	338426.
15	896.	82.	1706.	1055.	323457.
16	855.	75.	1656.	1000.	311112.
17	817.	69.	1558.	951.	293926.
18	767.	82.	1578.	874.	286955.
19	732.	56.	1362.	825.	256077.

**************** R E G I O N 5 T O T A L S************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	12872.	9396.	299015.	76189.	53320768.
1	12460.	9539.	234687.	67333.	43430528.
2	12584.	8675.	219963.	68379.	42141136.
3	13946.	6233.	127127.	51505.	24781424.
4	15340.	3614.	63886.	41055.	14663186.
5	16176.	2215.	39163.	32202.	9234131.
6	16905.	1457.	22003.	24920.	5952843.
7	17296.	745.	13855.	18948.	3944162.
8	16605.	2131.	18915.	18668.	4393816.
9	15828.	1584.	18230.	17529.	4150200.
10	15338.	1400.	15366.	16848.	3742399.
11	14966.	1610.	13771.	16587.	3532754.
12	14504.	1532.	14592.	16029.	3555610.
13	13899.	1519.	14769.	15224.	3484338.
14	13481.	1225.	13117.	14764.	3239017.
15	13060.	1468.	12796.	14311.	3148798.
16	12596.	1335.	12681.	13782.	3074482.
17	12170.	1231.	12089.	13315.	2951523.
18	11475.	1542.	13349.	12314.	2982886.
19	11047.	984.	10864.	11884.	2643979.

TABLE 21-B-3 (continued)

**************** NBTC SIMULATION MODEL ****************

•••••• BEEF MODEL ••• CALFHOOD VACCINATION 90% ••••••••

**************** R E G I O N 6 T O T A L S************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	735.	1050.	27961.	4003.	4527851.
1	721.	1149.	19842.	3643.	3416040.
2	682.	1124.	20303.	3602.	3490787.
3	841.	862.	11300.	3044.	2015079.
4	1049.	535.	5490.	2850.	1225562.
5	1196.	343.	3776.	2497.	864828.
6	1344.	248.	2109.	2143.	587904.
7	1455.	90.	1321.	1763.	407395.
8	1406.	291.	2029.	1759.	480529.
9	1336.	263.	2057.	1637.	463949.
10	1313.	216.	1601.	1601.	406479.
11	1300.	231.	1490.	1593.	392114.
12	1275.	227.	1546.	1557.	393486.
13	1223.	238.	1653.	1472.	394288.
14	1199.	194.	1401.	1446.	361399.
15	1172.	217.	1392.	1413.	355628.
16	1135.	208.	1412.	1361.	350802.
17	1102.	194.	1334.	1319.	335890.
18	1023.	241.	1548.	1192.	343385.
19	988.	164.	1182.	1152.	295606.

**************** R E G I O N 7 T O T A L S************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	407.	323.	10910.	1900.	1823039.
1	358.	400.	7100.	1510.	1242884.
2	319.	369.	6676.	1410.	1172652.
3	330.	281.	3889.	1022.	675171.
4	352.	183.	2106.	825.	413173.
5	364.	115.	1462.	670.	283544.
6	382.	82.	834.	568.	188673.
7	394.	30.	560.	473.	134077.
8	367.	76.	866.	450.	163984.
9	340.	73.	824.	400.	151314.
10	326.	57.	640.	377.	127196.
11	317.	51.	558.	379.	117717.
12	303.	55.	619.	356.	121622.
13	286.	57.	608.	330.	116759.
14	275.	47.	533.	317.	106444.
15	264.	47.	516.	306.	102845.
16	252.	47.	510.	292.	100047.
17	242.	44.	482.	279.	95156.
18	223.	51.	529.	246.	95762.
19	213.	38.	399.	237.	79694.

TABLE 21-B-3 (continued)

**************** NBTC SIMULATION MODEL ****************

...... BEEF MODEL ... CALFHOOD VACCINATION 90% ....

**************** R E G I O N 8 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	24.	20.	446.	69.	73887.
1	23.	25.	409.	74.	70118.
2	22.	27.	493.	78.	82300.
3	21.	27.	532.	79.	88107.
4	21.	25.	514.	83.	86445.
5	20.	26.	547.	79.	89958.
6	20.	23.	499.	78.	83407.
7	19.	22.	490.	75.	81507.
8	16.	23.	495.	59.	78800.
9	13.	21.	416.	47.	65616.
10	12.	17.	332.	45.	53939.
11	12.	15.	315.	44.	51616.
12	11.	15.	320.	42.	51868.
13	10.	15.	313.	37.	49862.
14	10.	14.	273.	36.	44397.
15	10.	13.	271.	36.	43937.
16	9.	13.	269.	33.	43156.
17	9.	12.	252.	32.	40688.
18	8.	13.	258.	27.	40342.
19	8.	11.	214.	26.	34397.

TABLE 21-D-3

**************** NBTC SIMULATION MODEL ****************

•••••• DAIRY MODEL ••• CALFHOOD VACCINATION 90% ••••••••

**************** U. S. T O T A L S**********************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	209.	835.	16800.	1400.	403522.	38057984.
1	165.	815.	15423.	1285.	363686.	35278160.
2	153.	773.	12622.	1052.	299638.	28752864.
3	142.	682.	8196.	683.	184823.	18292416.
4	106.	504.	5247.	437.	118930.	12322423.
5	78.	310.	3438.	286.	76499.	8449593.
6	58.	236.	2476.	206.	56370.	6597349.
7	44.	131.	2031.	169.	46781.	5719696.
8	35.	184.	1894.	158.	43983.	5465301.
9	32.	160.	1799.	150.	41934.	5273401.
10	29.	133.	1714.	143.	39970.	5080861.
11	27.	123.	1645.	137.	38365.	4919294.
12	26.	117.	1596.	133.	37225.	4803277.
13	25.	112.	1558.	130.	36334.	4712889.
14	24.	108.	1520.	127.	35422.	4620161.
15	23.	104.	1486.	124.	34636.	4539679.
16	23.	100.	1460.	122.	34014.	4475488.
17	22.	97.	1436.	120.	33463.	4418843.
18	21.	94.	1415.	118.	32970.	4368108.
19	20.	90.	1389.	116.	32347.	4304058.

**************** R E G I O N 1 T O T A L S**************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	26.	103.	1605.	134.	38659.	4047638.
1	18.	86.	1288.	107.	30618.	3246943.
2	15.	72.	1043.	87.	24903.	2630215.
3	14.	64.	911.	76.	21773.	2296362.
4	12.	57.	799.	67.	19107.	2015221.
5	11.	51.	709.	59.	16958.	1787833.
6	10.	47.	637.	53.	15245.	1606162.
7	9.	44.	586.	49.	14040.	1478102.
8	9.	42.	551.	46.	13204.	1389227.
9	8.	38.	504.	42.	12067.	1270466.
10	7.	32.	438.	36.	10462.	1103231.
11	6.	27.	376.	31.	9000.	949236.
12	5.	25.	332.	28.	7933.	836048.
13	5.	22.	297.	25.	7101.	748023.
14	4.	19.	262.	22.	6273.	661126.
15	4.	17.	233.	19.	5580.	587960.
16	3.	16.	211.	18.	5044.	531253.
17	3.	14.	191.	16.	4584.	482722.
18	3.	13.	175.	15.	4185.	440658.
19	2.	11.	154.	13.	3686.	388438.

TABLE 21-D-3 (continued)

**************** NBTC SIMULATION MODEL *****************

...... DAIRY MODEL ... CALFHOOD VACCINATION 90% ....

**************** R E G I O N 2 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	2.	10.	61.	5.	1474.	147641.
1	1.	6.	58.	5.	1393.	141481.
2	1.	5.	53.	4.	1273.	129709.
3	1.	5.	49.	4.	1161.	118219.
4	1.	4.	44.	4.	1053.	107230.
5	1.	4.	40.	3.	963.	97998.
6	1.	4.	37.	3.	888.	90283.
7	1.	4.	35.	3.	838.	85124.
8	1.	4.	34.	3.	807.	81881.
9	1.	4.	32.	3.	756.	76730.
10	1.	3.	28.	2.	677.	68848.
11	1.	3.	25.	2.	604.	61380.
12	1.	3.	23.	2.	548.	55702.
13	1.	3.	21.	2.	502.	51034.
14	0.	2.	19.	2.	454.	46104.
15	0.	2.	17.	1.	412.	41837.
16	0.	2.	16.	1.	377.	38269.
17	0.	2.	14.	1.	345.	35003.
18	0.	2.	13.	1.	315.	32047.
19	0.	1.	12.	1.	279.	28377.

**************** R E G I O N 3 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	79.	314.	5207.	434.	125173.	10443844.
1	46.	240.	3957.	330.	93406.	7933941.
2	38.	192.	2978.	248.	70720.	5971107.
3	33.	158.	1666.	139.	37049.	3141852.
4	23.	109.	857.	71.	18988.	1615977.
5	16.	59.	403.	34.	8386.	720032.
6	11.	40.	177.	15.	3687.	316813.
7	7.	17.	78.	6.	1561.	134594.
8	5.	26.	51.	4.	1016.	87632.
9	4.	22.	38.	3.	760.	65221.
10	4.	17.	33.	3.	658.	56260.
11	4.	16.	30.	3.	614.	52455.
12	4.	15.	29.	2.	589.	50282.
13	4.	15.	28.	2.	570.	48655.
14	3.	14.	27.	2.	551.	46999.
15	3.	14.	26.	2.	532.	45384.
16	3.	13.	25.	2.	515.	43955.
17	3.	13.	25.	2.	499.	42546.
18	3.	12.	24.	2.	482.	41134.
19	3.	12.	23.	2.	463.	39485.

TABLE 21-D-3 (continued)

***************** NBTC SIMULATION MODEL *****************

...... DAIRY MODEL ... CALFHOOD VACCINATION 90% ....

***************** R E G I O N 4 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	19.	77.	5341.	445.	127983.	12591584.
1	10.	71.	4966.	414.	115681.	11701157.
2	7.	71.	3203.	267.	74809.	7545854.
3	6.	51.	1554.	130.	34171.	3446292.
4	4.	38.	812.	68.	17828.	1799584.
5	3.	26.	404.	34.	8335.	848453.
6	2.	17.	183.	15.	3778.	385186.
7	1.	9.	81.	7.	1606.	164465.
8	1.	7.	52.	4.	1029.	105445.
9	1.	5.	35.	3.	705.	72026.
10	1.	4.	28.	2.	556.	56522.
11	1.	4.	25.	2.	493.	49970.
12	1.	3.	23.	2.	455.	46123.
13	1.	3.	21.	2.	429.	43441.
14	1.	3.	20.	2.	406.	41178.
15	0.	3.	19.	2.	386.	39084.
16	0.	3.	18.	2.	367.	37188.
17	0.	3.	17.	1.	350.	35443.
18	0.	3.	17.	1.	334.	33790.
19	0.	2.	16.	1.	317.	32104.

***************** R E G I O N 5 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	51.	205.	2840.	237.	68287.	6042082.
1	64.	292.	3277.	273.	78322.	6968174.
2	67.	317.	3672.	306.	88069.	7809532.
3	65.	299.	2571.	214.	57362.	5142700.
4	47.	215.	1471.	123.	32639.	2942706.
5	33.	113.	735.	61.	15295.	1393447.
6	22.	79.	332.	28.	6901.	629681.
7	15.	21.	147.	12.	2943.	269663.
8	10.	57.	96.	8.	1914.	175362.
9	9.	47.	70.	6.	1414.	129016.
10	8.	35.	60.	5.	1209.	109790.
11	8.	33.	56.	5.	1122.	101791.
12	8.	31.	53.	4.	1076.	97521.
13	7.	30.	52.	4.	1041.	94392.
14	7.	29.	50.	4.	1005.	91111.
15	7.	28.	48.	4.	969.	87872.
16	7.	27.	47.	4.	939.	85102.
17	6.	26.	45.	4.	908.	82339.
18	6.	25.	43.	4.	878.	79556.
19	6.	24.	42.	3.	842.	76306.

TABLE 21-D-3 (continued)

***************** NBTC SIMULATION MODEL *****************

...... DAIRY MODEL ... CALFHOOD VACCINATION 90% ....

*************** R E G I O N 6 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	14.	55.	524.	44.	12625.	1170281.
1	15.	69.	573.	48.	13766.	1278924.
2	15.	69.	610.	51.	14682.	1362526.
3	14.	63.	396.	33.	8857.	830840.
4	10.	44.	209.	17.	4651.	438444.
5	7.	23.	99.	8.	2075.	197469.
6	5.	16.	44.	4.	924.	88039.
7	3.	4.	20.	2.	401.	38347.
8	2.	13.	13.	1.	270.	25845.
9	2.	11.	11.	1.	216.	20527.
10	2.	8.	10.	1.	193.	18308.
11	2.	8.	9.	1.	183.	17313.
12	2.	7.	9.	1.	178.	16835.
13	2.	7.	9.	1.	174.	16471.
14	2.	7.	8.	1.	169.	15965.
15	2.	7.	8.	1.	163.	15481.
16	2.	7.	8.	1.	159.	15095.
17	2.	6.	8.	1.	155.	14666.
18	2.	6.	7.	1.	150.	14218.
19	1.	6.	7.	1.	143.	13551.

*************** R E G I O N 7 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	14.	54.	791.	66.	18977.	2197087.
1	6.	30.	541.	45.	12702.	1504141.
2	4.	21.	368.	31.	8697.	1022447.
3	3.	15.	193.	16.	4265.	504265.
4	2.	9.	93.	8.	2053.	243520.
5	1.	4.	41.	3.	859.	102727.
6	1.	3.	17.	1.	361.	43151.
7	1.	1.	7.	1.	149.	17894.
8	0.	3.	5.	0.	98.	11764.
9	0.	2.	4.	0.	74.	8790.
10	0.	2.	3.	0.	63.	7497.
11	0.	1.	3.	0.	58.	6879.
12	0.	1.	3.	0.	55.	6504.
13	0.	1.	3.	0.	52.	6212.
14	0.	1.	2.	0.	50.	5931.
15	0.	1.	2.	0.	48.	5675.
16	0.	1.	2.	0.	46.	5453.
17	0.	1.	2.	0.	44.	5246.
18	0.	1.	2.	0.	43.	5049.
19	0.	1.	2.	0.	41.	4817.

TABLE 21-D-3 (continued)

**************** NBTC SIMULATION MODEL *****************

...... DAIRY MODEL ... CALFHOOD VACCINATION 90% ....

**************** R E G I O N 8 T O T A L S************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	4.	17.	432.	36.	10343.	1417862.
1	5.	21.	763.	64.	17799.	2503442.
2	6.	26.	695.	58.	16485.	2281511.
3	6.	27.	856.	71.	20184.	2811895.
4	6.	29.	962.	80.	22612.	3159744.
5	6.	30.	1006.	84.	23628.	3301636.
6	6.	30.	1047.	87.	24586.	3438038.
7	6.	31.	1076.	90.	25243.	3531511.
8	7.	31.	1093.	91.	25643.	3588150.
9	7.	31.	1106.	92.	25943.	3630629.
10	7.	31.	1115.	93.	26152.	3660408.
11	7.	31.	1121.	93.	26292.	3680272.
12	7.	31.	1125.	94.	26391.	3694263.
13	7.	32.	1128.	94.	26464.	3704662.
14	7.	32.	1131.	94.	26514.	3711748.
15	7.	32.	1132.	94.	26547.	3716386.
16	7.	32.	1133.	94.	26566.	3719174.
17	7.	32.	1133.	94.	26578.	3720880.
18	7.	32.	1134.	94.	26583.	3721657.
19	7.	32.	1133.	94.	26578.	3720980.

The relevant infection and loss data for beef herds are listed in Tables 21-B-1, 21-B-2, and 21-B-3 for the three levels of herd vaccination. These data are shown for the total U. S. and by regions. The general impacts on brucellosis infection of increasing the level of herd vaccination were: (1) to reduce the level of infection within the herd thus reducing the probability of herd detection; (2) increasing the clean-up rate and thereby reducing both the number of tests to clean-up and the number of quarantined herds; and (3) materially reducing both the number of infected cows and the level of physical losses. Interestingly, the number of undetected infected herds decreased less under the high vaccination level than under lower levels of vaccination owing to the low probability of detection associated with high-level vaccinated herds. However, the rate of decline in numbers of quarantined herds, infected cows and beef losses increased as the level of herd vaccination increased. Under the low level of herd vaccination, annual beef losses (liveweight weaned calf) were reduced from 80.3 million pounds in year 0 to 19.5 million pounds in year 19. Under the medium level of herd vaccination, annual losses were reduced slightly more--to 8.8 million pounds. When the level of herd vaccination was increased to 90 percent, however, annual beef losses were reduced to 4.2 million pounds, representing a 95 percent reduction from the rate prevailing in year 0 when accelerated vaccination was begun in the five regions.

Corresponding data for dairy herds are listed in Tables 21-D-1, 21-D-2, and 21-D-3, respectively. Annual milk losses were reduced from 38.1 million pounds in year 0 to 9.2 million pounds in year 19 under the low level of herd vaccination. The medium level of herd vaccination reduced milk losses to 5.2 million pounds. When the herd vaccination level reached 90 percent, losses were further reduced to 4.3 million pounds of milk per year.

4. Whole Herd Vaccination in Areas of High Prevalence

In program option 4, whole-herd vaccination was administered in Regions 3, 4, 5, following herd testing. The primary advantage of whole-herd vaccination for either infected herds or non-infected herds at risk is that the level of vaccination protection can be achieved much faster throughout the herd than with calfhood vaccination. Under this option, both calves and adults were vaccinated, initially. Once the percent of herd vaccination reached the specified level, however, it was maintained by calfhood vaccination only. In the model, Region 3 entered the whole-herd vaccination program in year 1, Region 5 in year 2, and Region 4 in year 3. The model assumed that all of the herds in the relevant regions moved into the low level (20-59 percent) vaccinal protection range in one year, into the medium level (60-89 percent) in two years and into the high level of protection range (90 percent) in three years, with one third of the herds in the region being vaccinated per year over a three year period.

The relevant data depicting the impact of whole-herd vaccination on levels of infection and physical losses are shown in the Table 22 series below. Table 22-B-1 summarizes projections for beef herds assuming a low level of herd vaccination, with Tables 22-B-2 and 22-B-3

showing projections for beef herds at high vaccination levels, respectively.

Many of the conclusions reached from program option 3, calfhood vaccination, apply as well to whole herd vaccination: namely, that vaccination materially reduces both the number of infected cows and physical losses. It also reduces the number of quarantined herds by increasing clean-up rates. However, it is less effective in reducing the number of infected, undetected herds because by reducing infection spread within herds, it reduces detection probabilities.

With the low level of vaccination program, annual beef losses were reduced from 80.2 million pounds in year 0 to 16.8 million pounds in year 19, (see Table 22-B-1). Moving the herd-vaccination up to the medium level decreased annual beef losses to 10.1 million pounds (Table 22-B-2). With the high level of herd vaccination, annual losses were reduced to 6.4 million pounds by year 19. Moreover, for each

TABLE 22-B-1

**************** NBTC SIMULATION MODEL ****************

...... BEEF MODEL...TESTING & WHOLE HERD VAC.39.5%........

**************** U. S. T O T A L S********************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	20465.	15014.	452329.	111862.	80253744.
1	19888.	15545.	331467.	93059.	60614544.
2	18634.	13564.	241665.	63212.	41891136.
3	15124.	8989.	163409.	61566.	31033104.
4	18528.	7424.	143279.	66491.	28966672.
5	18160.	8329.	167888.	65836.	32000976.
6	18785.	7429.	152782.	69807.	30697008.
7	19331.	7688.	163274.	73346.	32624928.
8	17872.	10070.	204634.	66175.	30733520.
9	16334.	9905.	188940.	59256.	33616128.
10	15755.	8204.	159162.	56210.	29335152.
11	15452.	7338.	146037.	55255.	27503472.
12	14769.	7500.	147025.	52415.	27143008.
13	13641.	7661.	145373.	48018.	26212528.
14	13170.	6605.	126746.	46020.	23526416.
15	12540.	6375.	123417.	43632.	22714944.
16	11803.	6225.	118309.	40917.	21618704.
17	11193.	5795.	110256.	38640.	20219600.
18	9918.	6160.	110927.	34223.	19560240.
19	9415.	4978.	91805.	32143.	16796880.

**************** R E G I O N 1 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	148.	150.	2593.	570.	457179.
1	150.	150.	2022.	565.	383536.
2	143.	143.	1992.	551.	377976.
3	135.	132.	1942.	533.	366131.
4	140.	112.	1702.	559.	338135.
5	139.	119.	1855.	556.	358391.
6	146.	110.	1734.	590.	348227.
7	153.	114.	1843.	621.	368810.
8	135.	145.	2273.	542.	412647.
9	111.	143.	2110.	439.	371675.
10	105.	109.	1584.	416.	295754.
11	103.	97.	1461.	407.	276748.
12	95.	98.	1480.	377.	273505.
13	82.	100.	1465.	323.	261493.
14	78.	82.	1190.	307.	221055.
15	74.	76.	1135.	291.	210488.
16	67.	75.	1112.	265.	202474.
17	62.	68.	1004.	246.	184215.
18	47.	74.	1081.	180.	181581.
19	45.	53.	717.	172.	131267.

TABLE 22-B-1 (continued)

***************** NBTC SIMULATION MODEL *****************

...... BEEF MODEL...TESTING & WHOLE HERD VAC.39.5%........

**************** R E G I O N 2 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	33.	27.	324.	97.	61575.
1	43.	37.	430.	122.	81732.
2	42.	40.	499.	127.	91777.
3	43.	39.	519.	132.	95403.
4	47.	36.	481.	148.	93424.
5	49.	40.	562.	154.	105351.
6	53.	38.	542.	171.	105929.
7	58.	41.	600.	187.	116800.
8	53.	54.	765.	165.	134752.
9	47.	54.	699.	140.	121240.
10	45.	44.	556.	137.	101191.
11	46.	40.	521.	140.	97053.
12	44.	42.	553.	134.	100071.
13	40.	43.	556.	120.	98124.
14	39.	37.	476.	118.	86644.
15	37.	36.	470.	113.	84943.
16	35.	36.	461.	105.	82162.
17	33.	33.	424.	99.	76071.
18	27.	36.	444.	80.	75336.
19	26.	29.	336.	77.	60093.

**************** R E G I O N 3 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	5092.	3462.	79878.	20316.	14331217.
1	5000.	3637.	42126.	12084.	7340488.
2	5143.	2440.	26146.	13277.	5479028.
3	5082.	2139.	27169.	13756.	5605206.
4	5209.	1939.	25780.	14582.	5543916.
5	5226.	2090.	29094.	14723.	5986537.
6	5434.	1957.	26870.	15710.	5872642.
7	5624.	2024.	29426.	16585.	6336193.
8	5295.	2655.	38731.	14950.	7230795.
9	4925.	2709.	34738.	13459.	6494236.
10	4881.	2199.	27834.	13365.	5615525.
11	4840.	2038.	27067.	13329.	5508680.
12	4728.	2068.	27439.	13037.	5501684.
13	4407.	2236.	29120.	11909.	5523349.
14	4338.	1904.	23903.	11757.	4853177.
15	4135.	1904.	25002.	11127.	4882372.
16	3945.	1876.	23790.	10434.	4621186.
17	3770.	1757.	22077.	9884.	4316917.
18	3372.	1393.	22676.	8769.	4212038.
19	3224.	1540.	18488.	8334.	3619452.

TABLE 22-B-1 (continued)

**************** NBTC SIMULATION MODEL *****************

...... BEEF MODEL...TESTING & WHOLE HERD VAC.39.5%........

**************** R E G I O N 4 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	1149.	587.	31204.	8718.	5658272.
1	1133.	609.	24649.	7727.	4649237.
2	1124.	601.	24627.	7718.	4674376.
3	1024.	622.	19401.	4218.	3136456.
4	1035.	323.	10739.	4508.	2060480.
5	1021.	319.	11943.	4659.	2223889.
6	1030.	297.	12083.	4841.	2267284.
7	1039.	303.	12674.	4989.	2365336.
8	993.	364.	14069.	4819.	2514800.
9	931.	376.	13897.	4507.	2443628.
10	909.	319.	12479.	4362.	2243447.
11	895.	299.	11954.	4291.	2167871.
12	859.	304.	11957.	4180.	2150970.
13	823.	319.	11976.	3955.	2117628.
14	803.	280.	10978.	3840.	1974328.
15	780.	274.	10710.	3727.	1924114.
16	749.	275.	10532.	3580.	1876338.
17	723.	262.	10062.	3448.	1798895.
18	662.	287.	10174.	3164.	1769292.
19	636.	238.	8991.	3009.	1595696.

**************** R E G I O N 5 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	12872.	9396.	299015.	76189.	53320768.
1	12460.	9539.	234687.	67333.	43430528.
2	11170.	8836.	161239.	36505.	26577552.
3	10974.	4715.	89261.	38493.	17550960.
4	11234.	3904.	83278.	42222.	17154384.
5	10933.	4624.	101258.	41579.	19354288.
6	11308.	3982.	90764.	44182.	18416384.
7	11633.	4163.	96843.	46487.	19562064.
8	10707.	5616.	123295.	41909.	22222432.
9	9747.	5439.	115046.	37559.	20507280.
10	9254.	4564.	98402.	34892.	17980288.
11	9032.	3983.	87588.	34160.	16493436.
12	8524.	4138.	88762.	31901.	16268696.
13	7860.	4103.	85518.	29325.	15458447.
14	7489.	3566.	76098.	27678.	14006434.
15	7092.	3395.	72432.	26149.	13305652.
16	6655.	3276.	68953.	24573.	12611925.
17	6284.	3046.	64612.	23182.	11642740.
18	5549.	3257.	64650.	20571.	11436902.
19	5239.	2603.	53785.	19178.	9822534.

TABLE 22-B-1 (continued)

**************** NBTC SIMULATION MODEL ****************

...... BEEF MODEL...TESTING & WHOLE HERD VAC.39.5%........

**************** R E G I O N 6 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	735.	1050.	27961.	4003.	4527851.
1	721.	1149.	19842.	3643.	3416040.
2	671.	1109.	19994.	3545.	3435512.
3	574.	992.	18349.	3103.	3111192.
4	589.	818.	15389.	3215.	2739368.
5	543.	857.	17229.	2996.	2943609.
6	572.	787.	15324.	3162.	2724586.
7	593.	795.	16322.	3331.	2898943.
8	483.	966.	19486.	2750.	3201177.
9	401.	914.	16617.	2266.	2743694.
10	399.	738.	13699.	2222.	2310488.
11	386.	679.	13116.	2155.	2222163.
12	369.	657.	12672.	2067.	2143645.
13	306.	674.	12793.	1736.	2091617.
14	307.	568.	10540.	1716.	1783404.
15	294.	535.	10338.	1658.	1744701.
16	253.	541.	10307.	1438.	1692469.
17	230.	493.	9150.	1296.	1506819.
18	168.	476.	8626.	1059.	1416629.
19	176.	401.	7192.	998.	1182726.

**************** R E G I O N 7 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	407.	323.	10910.	1900.	1823039.
1	358.	400.	7100.	1510.	1242884.
2	319.	369.	6676.	1410.	1172652.
3	273.	324.	6269.	1258.	1085666.
4	254.	270.	5454.	1180.	961753.
5	230.	257.	5457.	1094.	947329.
6	221.	235.	5002.	1073.	883207.
7	214.	225.	5078.	1067.	894351.
8	188.	245.	5466.	972.	928628.
9	158.	246.	5143.	829.	856468.
10	146.	210.	4254.	761.	723978.
11	136.	184.	3956.	718.	675721.
12	125.	174.	3784.	667.	642678.
13	111.	168.	3578.	606.	603143.
14	103.	151.	3251.	561.	550267.
15	95.	139.	3028.	524.	512823.
16	87.	131.	2858.	483.	481985.
17	80.	122.	2656.	446.	447520.
18	64.	122.	2603.	370.	425179.
19	61.	102.	2078.	345.	349610.

TABLE 22-B-1 (continued)

*************** NBTC SIMULATION MODEL ***************

...... BEEF MODEL...TESTING & WHOLE HERD VAC.39.5%........

*************** R E G I O N & T O T A L S***************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	24.	20.	446.	69.	73887.
1	23.	25.	469.	74.	70118.
2	22.	27.	493.	78.	82300.
3	20.	26.	498.	73.	82122.
4	20.	23.	457.	76.	77236.
5	20.	24.	491.	75.	81603.
6	20.	22.	465.	78.	78783.
7	20.	23.	488.	81.	82474.
8	18.	26.	549.	69.	88318.
9	15.	26.	491.	57.	77938.
10	15.	21.	393.	55.	64515.
11	15.	19.	373.	56.	61835.
12	14.	19.	378.	52.	61800.
13	13.	19.	366.	45.	58737.
14	12.	17.	311.	45.	51137.
15	12.	16.	304.	43.	49879.
16	11.	16.	296.	40.	48187.
17	11.	15.	272.	38.	44456.
18	9.	15.	274.	31.	43315.
19	9.	12.	217.	30.	35508.

TABLE 22-D-1

**************** NBTC SIMULATION MODEL ****************

......DAIRY MODEL...TESTING & WHOLE HERD VAC.39.5%........

**************** U. S. T O T A L S*********************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	209.	835.	16800.	1400.	403522.	38057984.
1	163.	794.	14032.	1169.	326881.	32185568.
2	138.	686.	9917.	826.	228448.	22645072.
3	106.	532.	7385.	615.	167559.	16684192.
4	92.	452.	6288.	524.	143011.	14661307.
5	87.	421.	5579.	465.	127379.	13181111.
6	85.	403.	5221.	435.	119509.	12449265.
7	85.	400.	5092.	424.	116720.	12203414.
8	86.	406.	5087.	424.	116680.	12210739.
9	84.	396.	5036.	420.	115482.	12115363.
10	78.	373.	4872.	406.	111618.	11766922.
11	74.	352.	4675.	390.	107085.	11545189.
12	71.	339.	4515.	376.	103433.	10999778.
13	69.	326.	4378.	365.	100319.	10705030.
14	65.	309.	4216.	351.	96585.	10353837.
15	62.	294.	4057.	338.	92939.	10008459.
16	59.	281.	3912.	326.	89650.	9695522.
17	56.	267.	3771.	314.	86412.	9388656.
18	53.	254.	3631.	303.	83212.	9065278.
19	49.	235.	3459.	288.	79256.	8710971.

**************** R E G I O N 1 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	26.	103.	1605.	134.	38659.	4047638.
1	18.	86.	1238.	107.	30618.	3246943.
2	15.	69.	1012.	84.	24142.	2552173.
3	13.	59.	846.	71.	20209.	2134013.
4	11.	52.	734.	61.	17543.	1850374.
5	10.	49.	668.	56.	15991.	1684342.
6	10.	47.	630.	53.	15101.	1588986.
7	10.	46.	616.	51.	14774.	1553261.
8	10.	47.	619.	52.	14868.	1561927.
9	10.	46.	607.	51.	14571.	1531768.
10	9.	42.	566.	47.	13563.	1427904.
11	8.	38.	521.	43.	12476.	1313879.
12	8.	36.	487.	41.	11660.	1227315.
13	7.	34.	458.	38.	10984.	1155873.
14	7.	31.	424.	35.	10163.	1070073.
15	6.	29.	393.	33.	9410.	990833.
16	6.	27.	367.	31.	8787.	924949.
17	5.	25.	342.	29.	8197.	862919.
18	5.	23.	319.	27.	7633.	803623.
19	4.	21.	286.	24.	6853.	722227.

TABLE 22-D-1 (continued)

**************** NBTC SIMULATION MODEL ****************

......DAIRY MODEL...TESTING & WHOLE HERD VAC.39.5%........

**************** R E G I O N 2 T O T A L S************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	2.	10.	61.	5.	1474.	147641.
1	1.	6.	58.	5.	1393.	141481.
2	1.	5.	52.	4.	1225.	124963.
3	1.	4.	44.	4.	1053.	107403.
4	1.	4.	39.	3.	925.	94252.
5	1.	4.	36.	3.	858.	87200.
6	1.	4.	35.	3.	827.	83955.
7	1.	4.	35.	3.	831.	84204.
8	1.	4.	36.	3.	858.	86939.
9	1.	4.	36.	3.	863.	87466.
10	1.	4.	35.	3.	829.	84125.
11	1.	4.	33.	3.	790.	80163.
12	1.	4.	32.	3.	763.	77421.
13	1.	4.	31.	3.	740.	75061.
14	1.	3.	29.	2.	704.	71462.
15	1.	3.	28.	2.	671.	68090.
16	1.	3.	27.	2.	641.	65072.
17	1.	3.	26.	2.	610.	61901.
18	1.	3.	24.	2.	578.	58669.
19	1.	3.	22.	2.	528.	53699.

**************** R E G I O N 3 T O T A L S************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	79.	314.	5207.	434.	125173.	10443844.
1	44.	218.	2567.	214.	56601.	4641349.
2	27.	135.	1661.	138.	36646.	3131979.
3	21.	103.	1148.	99.	26270.	2239638.
4	19.	89.	943.	79.	20944.	1778923.
5	18.	83.	828.	69.	18436.	1561773.
6	17.	81.	775.	65.	17277.	1461117.
7	18.	81.	758.	63.	16908.	1428338.
8	18.	83.	761.	63.	17003.	1435352.
9	18.	82.	757.	63.	16904.	1427491.
10	17.	78.	734.	61.	16383.	1384483.
11	16.	75.	708.	59.	15789.	1334459.
12	16.	74.	688.	57.	15344.	1296468.
13	16.	72.	672.	56.	14968.	1266196.
14	15.	69.	648.	54.	14461.	1222161.
15	14.	67.	624.	52.	13930.	1177315.
16	14.	64.	601.	50.	13404.	1132841.
17	13.	61.	576.	48.	12849.	1086062.
18	13.	58.	550.	46.	12277.	1037781.
19	12.	54.	518.	43.	11548.	976599.

TABLE 22-D-1 (continued)

***************** NBTC SIMULATION MODEL *****************

......DAIRY MODEL...TESTING & WHOLE HERD VAC.39.5%........

***************** R E G I O N 4 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	19.	77.	5341.	445.	127983.	12591584.
1	10.	71.	4966.	414.	115681.	11701157.
2	7.	71.	3187.	266.	74440.	7510474.
3	6.	50.	1518.	126.	33335.	3364587.
4	4.	36.	1154.	96.	25322.	2559662.
5	3.	29.	883.	74.	19357.	1956704.
6	3.	24.	722.	60.	15909.	1600892.
7	3.	22.	661.	55.	14596.	1465796.
8	3.	22.	638.	53.	14088.	1413295.
9	3.	21.	625.	52.	13822.	1386292.
10	3.	21.	609.	51.	13463.	1350886.
11	3.	20.	588.	49.	12996.	1304351.
12	3.	19.	569.	47.	12562.	1260499.
13	3.	19.	552.	46.	12202.	1224182.
14	3.	18.	535.	45.	11821.	1186192.
15	2.	18.	517.	43.	11413.	1145371.
16	2.	17.	499.	42.	11022.	1106068.
17	2.	16.	482.	40.	10648.	1068580.
18	2.	16.	465.	39.	10271.	1030777.
19	2.	15.	444.	37.	9810.	984794.

***************** R E G I O N 5 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	51.	205.	2840.	237.	68287.	6042082.
1	64.	292.	3277.	273.	78322.	6908174.
2	64.	292.	2351.	196.	52593.	4700818.
3	43.	211.	2075.	173.	46053.	4151843.
4	37.	174.	1705.	142.	37768.	3411099.
5	35.	163.	1485.	124.	33014.	2970679.
6	34.	158.	1368.	116.	30885.	2775105.
7	34.	157.	1347.	112.	30014.	2694306.
8	35.	160.	1345.	112.	29992.	2690251.
9	34.	156.	1327.	111.	29579.	2654330.
10	31.	146.	1271.	106.	28311.	2542970.
11	29.	137.	1199.	100.	26698.	2398967.
12	28.	131.	1139.	95.	25355.	2277687.
13	27.	125.	1085.	90.	24156.	2169691.
14	25.	117.	1026.	85.	22834.	2051575.
15	24.	110.	967.	81.	21515.	1933242.
16	22.	104.	912.	76.	20310.	1824809.
17	21.	98.	861.	72.	19173.	1722694.
18	20.	93.	813.	68.	18090.	1625427.
19	18.	85.	757.	63.	16839.	1513588.

TABLE 22-D-1 (continued)

***************** NBTC SIMULATION MODEL *****************

......DAIRY MODEL...TESTING & WHOLE HERD VAC.39.5%........

*************** R E G I O N 6 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	14.	55.	524.	44.	12625.	1170281.
1	15.	69.	573.	48.	13766.	1278924.
2	14.	67.	591.	49.	14222.	1320743.
3	13.	62.	563.	47.	13484.	1256089.
4	12.	55.	508.	42.	12161.	1134317.
5	11.	51.	467.	39.	11181.	1042259.
6	10.	49.	437.	36.	10467.	975082.
7	10.	48.	422.	35.	10133.	943192.
8	10.	49.	421.	35.	10114.	940652.
9	10.	46.	408.	34.	9783.	910557.
10	9.	42.	378.	31.	9052.	843597.
11	8.	34.	349.	29.	8353.	778532.
12	8.	36.	327.	27.	7836.	729926.
13	7.	35.	310.	26.	7430.	691934.
14	7.	32.	288.	24.	6910.	643862.
15	6.	30.	269.	22.	6454.	601318.
16	6.	28.	254.	21.	6088.	567068.
17	6.	26.	237.	20.	5690.	530146.
18	5.	24.	220.	18.	5273.	491454.
19	5.	22.	199.	17.	4773.	445065.

*************** R E G I O N 7 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	14.	54.	791.	66.	18977.	2197087.
1	6.	30.	541.	45.	12702.	1504141.
2	4.	21.	368.	31.	8697.	1022447.
3	3.	16.	296.	25.	7008.	823011.
4	3.	13.	243.	20.	5757.	675889.
5	3.	12.	206.	17.	4872.	571269.
6	2.	11.	179.	15.	4243.	497012.
7	2.	10.	160.	13.	3803.	445080.
8	2.	9.	147.	12.	3504.	409692.
9	2.	8.	136.	11.	3243.	379177.
10	2.	8.	125.	10.	2962.	346448.
11	1.	7.	114.	9.	2697.	315553.
12	1.	6.	104.	9.	2473.	289247.
13	1.	6.	96.	8.	2280.	266588.
14	1.	5.	88.	7.	2096.	245164.
15	1.	5.	81.	7.	1931.	225861.
16	1.	5.	75.	6.	1786.	208897.
17	1.	4.	70.	6.	1655.	193509.
18	1.	4.	65.	5.	1535.	179476.
19	1.	3.	59.	5.	1400.	163873.

TABLE 22-D-1 (continued)

**************** NBTC SIMULATION MODEL ****************

......DAIRY MODEL...TESTING & WHOLE HERD VAC.39.5%........

**************** R E G I O N 6 T O T A L S************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	4.	17.	432.	36.	10343.	1417862.
1	5.	21.	763.	64.	17799.	2503442.
2	6.	26.	695.	58.	16485.	2281511.
3	6.	27.	855.	71.	20148.	2807020.
4	6.	29.	961.	80.	22591.	3156772.
5	6.	30.	1007.	84.	23671.	3306687.
6	6.	31.	1056.	88.	24801.	3467117.
7	7.	31.	1093.	91.	25661.	3589178.
8	7.	32.	1119.	93.	26252.	3672634.
9	7.	32.	1139.	95.	26716.	3738285.
10	7.	32.	1153.	96.	27056.	3786511.
11	7.	32.	1163.	97.	27286.	3819266.
12	7.	33.	1170.	97.	27441.	3841217.
13	7.	33.	1174.	98.	27541.	3855506.
14	7.	33.	1177.	98.	27596.	3863350.
15	7.	33.	1178.	98.	27617.	3866431.
16	7.	33.	1177.	98.	27612.	3865820.
17	7.	33.	1177.	98.	27590.	3862626.
18	7.	33.	1175.	98.	27555.	3858073.
19	7.	32.	1173.	98.	27505.	3851128.

TABLE 22-B-2

**************** NBTC SIMULATION MODEL ****************

...... BEEF MODEL...TESTING & WHOLE HERD VAC.74.5%........

**************** U. S. T O T A L S********************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	20465.	15014.	452329.	111862.	80253744.
1	19888.	15545.	331467.	93059.	60614544.
2	18677.	12884.	231787.	58938.	39735648.
3	17972.	6545.	120910.	43544.	21822192.
4	17842.	4643.	81360.	44742.	16641380.
5	17516.	4961.	87601.	45301.	17315808.
6	17638.	4448.	83003.	46716.	16937296.
7	17771.	4562.	87591.	48025.	17689008.
8	16908.	5638.	101969.	45465.	19054256.
9	15562.	5887.	101941.	40947.	18362944.
10	15137.	4544.	83271.	39730.	15902111.
11	14829.	4298.	79603.	39086.	15344387.
12	14357.	4375.	79126.	37959.	15111857.
13	13522.	4603.	80744.	35569.	14954535.
14	13139.	3911.	71938.	34586.	13733768.
15	12703.	3884.	70366.	33471.	13383758.
16	12127.	3899.	69624.	31872.	13056947.
17	11644.	3649.	65676.	30541.	12376937.
18	10234.	4449.	73048.	25908.	12607815.
19	9828.	2967.	53552.	24798.	10076684.

**************** R E G I O N 1 T O T A L S************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	148.	150.	2593.	570.	457179.
1	150.	150.	2022.	565.	383536.
2	143.	143.	1992.	551.	377976.
3	134.	130.	1922.	526.	361977.
4	135.	108.	1642.	537.	325105.
5	130.	111.	1725.	519.	332659.
6	133.	100.	1559.	535.	313046.
7	135.	101.	1608.	547.	321806.
8	116.	124.	1930.	464.	350210.
9	93.	120.	1752.	368.	308631.
10	87.	89.	1266.	341.	240296.
11	83.	78.	1166.	328.	221053.
12	76.	78.	1165.	299.	215349.
13	64.	78.	1141.	252.	203711.
14	61.	63.	920.	238.	170967.
15	57.	59.	874.	225.	162161.
16	52.	58.	857.	204.	155918.
17	48.	53.	775.	190.	142144.
18	36.	58.	838.	140.	140716.
19	34.	41.	556.	133.	101556.

TABLE 22-B-2 (continued)

**************** NBTC SIMULATION MODEL ****************

•••••• BEEF MODEL•••TESTING & WHOLE HERD VAC•74•5%••••••••

**************** R E G I O N 2 T O T A L S*************

YEAR	UNDETECTED INF•HERDS	QUARNTD• HERDS	QUARNTD• INF•COWS	INFECTED COWS	CALF LOSS POUNDS
0	38•	27•	324•	97•	61575•
1	43•	37•	430•	122•	81732•
2	42•	40•	499•	127•	91777•
3	42•	38•	495•	127•	90857•
4	44•	33•	441•	138•	85601•
5	44•	35•	493•	138•	92532•
6	47•	33•	460•	149•	90112•
7	50•	35•	494•	158•	96530•
8	44•	44•	615•	136•	108564•
9	38•	44•	555•	114•	96565•
10	37•	35•	435•	110•	79400•
11	36•	31•	402•	110•	75063•
12	34•	32•	421•	104•	76375•
13	31•	33•	420•	92•	74151•
14	30•	28•	358•	89•	65218•
15	28•	27•	352•	85•	63622•
16	26•	27•	345•	79•	61497•
17	25•	25•	318•	74•	57055•
18	20•	27•	334•	60•	56699•
19	19•	21•	252•	57•	44929•

**************** R E G I O N 3 T O T A L S*************

YEAR	UNDETECTED INF•HERDS	QUARNTD• HERDS	QUARNTD• INF•COWS	INFECTED COWS	CALF LOSS POUNDS
0	5092•	3462•	79878•	20316•	14331217•
1	5000•	3637•	42126•	12084•	7340488•
2	5185•	1760•	16267•	9003•	3323542•
3	5186•	1214•	12268•	9990•	2895099•
4	5180•	1114•	13095•	10494•	3000943•
5	5142•	1192•	14200•	10504•	3130332•
6	5211•	1096•	13146•	10835•	3052669•
7	5275•	1127•	13786•	11133•	3169748•
8	5076•	1423•	16778•	10567•	3453150•
9	4672•	1595•	18266•	9282•	3474010•
10	4582•	1184•	13536•	9166•	2883020•
11	4528•	1095•	12863•	9136•	2793016•
12	4418•	1139•	13132•	8948•	2797320•
13	4209•	1215•	13652•	8488•	2794214•
14	4115•	1054•	12153•	8302•	2591166•
15	4004•	1044•	11985•	8084•	2541302•
16	3852•	1058•	12022•	7754•	2499988•
17	3722•	1002•	11420•	7472•	2389296•
18	3331•	1230•	13553•	6346•	2492611•
19	3215•	863•	9166•	6169•	1944890•

TABLE 22-B-2 (continued)

**************** NBTC SIMULATION MODEL ****************

...... BEEF MODEL...TESTING & WHOLE HERD VAC.74.5%........

**************** R E G I O N 4 T O T A L S************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	1149.	587.	31204.	6718.	5658272.
1	1133.	609.	24849.	7727.	4649237.
2	1124.	601.	24627.	7718.	4674376.
3	1023.	521.	19387.	4215.	3134109.
4	986.	255.	6215.	2573.	1357844.
5	963.	172.	5251.	2736.	1008970.
6	955.	160.	5695.	2894.	1077623.
7	947.	162.	6249.	3002.	1160186.
8	903.	202.	7163.	2919.	1257999.
9	845.	206.	7177.	2732.	1233147.
10	817.	157.	6403.	2629.	1126816.
11	796.	158.	6102.	2578.	1084722.
12	767.	163.	6138.	2501.	1078334.
13	725.	172.	6149.	2357.	1059498.
14	701.	145.	5590.	2273.	981015.
15	675.	144.	5427.	2195.	951393.
16	645.	144.	5330.	2102.	926733.
17	619.	135.	5079.	2013.	884587.
18	569.	154.	5142.	1838.	867824.
19	544.	118.	4457.	1735.	771401.

**************** R E G I O N 5 T O T A L S************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	12872.	9395.	299015.	76189.	53320768.
1	12460.	9539.	234687.	67333.	43430528.
2	11170.	8336.	161239.	36505.	26577552.
3	10727.	3210.	61914.	24285.	11095268.
4	10692.	2087.	38031.	26859.	8355580.
5	10530.	2458.	45884.	27754.	9318064.
6	10614.	2187.	44935.	28684.	9353185.
7	10680.	2301.	48015.	29573.	9853650.
8	10216.	2890.	55907.	28406.	10641587.
9	9459.	3018.	57141.	26014.	10453226.
10	9180.	2335.	47752.	25160.	9224987.
11	8971.	2269.	45822.	24697.	8922507.
12	8672.	2319.	45435.	23980.	8773923.
13	8162.	2443.	46524.	22541.	8707576.
14	7906.	2054.	41897.	21880.	8663706.
15	7624.	2071.	40897.	21132.	7839333.
16	7273.	2067.	40243.	20169.	7626623.
17	6973.	1928.	38191.	19348.	7268514.
18	6065.	2479.	43439.	16320.	7462186.
19	5816.	1501.	31196.	15573.	5910198.

TABLE 22-B-2 (continued)

**************** NBTC SIMULATION MODEL *****************

...... BEEF MODEL...TESTING & WHOLE HERD VAC.74.5%........

***************** R E G I O N 6 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	735.	1050.	27961.	4003.	4527851.
1	721.	1149.	19842.	3643.	3416040.
2	671.	1109.	19994.	3545.	3435512.
3	568.	982.	18157.	3069.	3077131.
4	540.	762.	14226.	2936.	2517055.
5	473.	736.	14665.	2579.	2502716.
6	477.	646.	12465.	2599.	2214634.
7	474.	626.	12764.	2627.	2265029.
8	374.	731.	14679.	2103.	2412776.
9	305.	683.	12535.	1707.	2046252.
10	299.	548.	10145.	1657.	1715761.
11	284.	504.	9775.	1606.	1655117.
12	274.	489.	9478.	1540.	1601615.
13	229.	504.	9646.	1304.	1576270.
14	232.	431.	8084.	1304.	1365895.
15	225.	412.	8045.	1276.	1355510.
16	196.	423.	8148.	1124.	1336358.
17	181.	392.	7369.	1031.	1211764.
18	150.	384.	7228.	857.	1158790.
19	140.	324.	5886.	806.	965964.

***************** R E G I O N 7 T O T A L S**************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	407.	323.	10910.	1900.	1823039.
1	353.	400.	7100.	1510.	1242884.
2	319.	369.	6676.	1410.	1172652.
3	273.	324.	6269.	1258.	1085666.
4	245.	262.	5267.	1131.	924771.
5	216.	235.	4930.	1002.	855524.
6	203.	206.	4329.	949.	765879.
7	191.	192.	4252.	915.	750444.
8	163.	202.	4434.	810.	755128.
9	135.	200.	4105.	681.	685747.
10	123.	169.	3386.	620.	577743.
11	114.	148.	3159.	584.	540834.
12	104.	140.	3038.	542.	516634.
13	92.	135.	2899.	494.	488953.
14	85.	123.	2666.	461.	451557.
15	79.	114.	2521.	434.	426741.
16	72.	109.	2417.	405.	407064.
17	67.	102.	2280.	379.	383597.
18	54.	104.	2265.	319.	369547.
19	51.	87.	1821.	297.	305259.

TABLE 22-D-2 (continued)

**************** NBTC SIMULATION MODEL ****************

...... BEEF MODEL...TESTING & WHOLE HERD VAC.74.5%.........

**************** R E G I O N   8   T O T A L S************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	24.	20.	446.	69.	73687.
1	23.	25.	409.	74.	70118.
2	22.	27.	493.	78.	82300.
3	20.	26.	498.	73.	82122.
4	19.	22.	442.	73.	74483.
5	18.	22.	452.	69.	75037.
6	16.	20.	414.	71.	70173.
7	18.	20.	423.	71.	71646.
8	16.	22.	464.	60.	74873.
9	14.	22.	411.	49.	65380.
10	13.	18.	329.	47.	54091.
11	13.	16.	313.	48.	52076.
12	12.	16.	319.	45.	52309.
13	11.	16.	312.	39.	50164.
14	11.	14.	268.	39.	44245.
15	11.	14.	266.	38.	43697.
16	10.	14.	263.	35.	42769.
17	10.	13.	244.	34.	39982.
18	8.	14.	249.	28.	39443.
19	9.	11.	199.	27.	32490.

TABLE 22-D-2

**************** NBTC SIMULATION MODEL ****************

......DAIRY MODEL...TESTING & WHOLE HERD VAC.74.5%........

**************** U. S.   T O T A L S**********************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	209.	835.	16800.	1400.	403522.	36057984.
1	163.	734.	14032.	1169.	326881.	32165568.
2	137.	653.	9353.	779.	214609.	21473904.
3	99.	443.	6158.	513.	137586.	14262783.
4	73.	337.	4626.	386.	103179.	11046207.
5	64.	293.	3874.	323.	87223.	9539918.
6	60.	269.	3459.	288.	78442.	8713596.
7	59.	259.	3270.	273.	74434.	8342979.
8	58.	256.	3197.	266.	72869.	8203717.
9	56.	247.	3123.	260.	71177.	8051754.
10	52.	230.	3000.	250.	68319.	7783400.
11	49.	217.	2875.	240.	65460.	7507649.
12	48.	209.	2780.	232.	63287.	7294570.
13	46.	202.	2703.	225.	61547.	7123253.
14	44.	192.	2618.	218.	59584.	6931173.
15	42.	184.	2538.	212.	57774.	6752811.
16	41.	178.	2471.	206.	56259.	6602324.
17	39.	171.	2406.	200.	54793.	6457683.
18	37.	164.	2342.	195.	53355.	6316291.
19	35.	152.	2254.	188.	51356.	6122190.

**************** R E G I O N   1 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	26.	103.	1605.	134.	38659.	4047638.
1	18.	86.	1288.	107.	30618.	3246943.
2	15.	69.	1012.	84.	24142.	2552173.
3	12.	58.	833.	69.	19886.	2100898.
4	11.	50.	707.	59.	16694.	1783046.
5	10.	46.	628.	52.	15033.	1584355.
6	9.	43.	578.	48.	13834.	1456599.
7	9.	41.	549.	46.	13168.	1385186.
8	9.	41.	537.	45.	12883.	1354246.
9	8.	38.	512.	43.	12284.	1292087.
10	7.	34.	465.	39.	11121.	1171566.
11	7.	30.	416.	35.	9964.	1049944.
12	6.	28.	380.	32.	9096.	957945.
13	6.	26.	351.	29.	8397.	884039.
14	5.	23.	319.	27.	7636.	804261.
15	5.	21.	291.	24.	6972.	734301.
16	4.	20.	269.	22.	6445.	678564.
17	4.	18.	249.	21.	5972.	628089.
18	4.	17.	231.	19.	5541.	583302.
19	3.	15.	207.	17.	4953.	522001.

TABLE 22-D-2 (continued)

**************** NBTC SIMULATION MODEL *****************

......DAIRY MODEL...TESTING & WHOLE HERD VAC.74.5%.........

**************** R E G I O N 2 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	2.	10.	61.	5.	1474.	147641.
1	1.	6.	58.	5.	1393.	141461.
2	1.	5.	52.	4.	1225.	124963.
3	1.	4.	43.	4.	1031.	105246.
4	1.	4.	37.	3.	877.	89445.
5	1.	4.	33.	3.	786.	79963.
6	1.	4.	31.	3.	735.	74628.
7	1.	4.	30.	2.	716.	72626.
8	1.	4.	30.	3.	720.	72928.
9	1.	4.	30.	2.	706.	71544.
10	1.	3.	28.	2.	662.	67176.
11	1.	3.	26.	2.	616.	62606.
12	1.	3.	24.	2.	584.	59244.
13	1.	3.	23.	2.	556.	56432.
14	1.	3.	22.	2.	521.	52667.
15	1.	2.	20.	2.	489.	49697.
16	0.	2.	19.	2.	463.	46991.
17	0.	2.	18.	2.	437.	44337.
18	0.	2.	17.	1.	412.	41803.
19	0.	2.	16.	1.	374.	38018.

**************** R E G I O N 3 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	79.	314.	5207.	434.	125173.	10443844.
1	44.	218.	2567.	214.	56601.	4641349.
2	26.	102.	1097.	91.	22807.	1960613.
3	16.	67.	698.	58.	14466.	1247408.
4	12.	52.	472.	39.	9820.	843359.
5	11.	46.	366.	30.	7649.	653632.
6	11.	43.	320.	27.	6706.	571444.
7	11.	42.	300.	25.	6297.	535706.
8	11.	42.	293.	24.	6148.	522563.
9	10.	41.	287.	24.	6030.	512534.
10	10.	39.	275.	23.	5784.	491862.
11	9.	37.	263.	22.	5527.	470036.
12	9.	37.	255.	21.	5348.	454634.
13	9.	36.	248.	21.	5215.	443306.
14	9.	34.	241.	20.	5055.	429798.
15	8.	33.	233.	19.	4891.	415837.
16	8.	32.	226.	19.	4744.	403290.
17	8.	31.	219.	18.	4594.	390547.
18	8.	30.	211.	18.	4438.	377327.
19	7.	28.	200.	17.	4189.	356366.

TABLE 22-D-2 (continued)

**************** NBTC SIMULATION MODEL ****************

......DAIRY MODEL...TESTING & WHOLE HERD VAC.74.5%........

**************** R E G I O N   4   T O T A L S************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	19.	77.	5341.	445.	127983.	12591584.
1	10.	71.	4966.	414.	115681.	11701157.
2	7.	71.	3187.	266.	74440.	7510474.
3	6.	50.	1510.	126.	33166.	3348222.
4	4.	33.	754.	63.	15573.	1583454.
5	2.	22.	522.	44.	10752.	1097174.
6	2.	16.	359.	30.	7421.	755312.
7	2.	13.	283.	24.	5871.	594404.
8	2.	12.	255.	21.	5310.	536430.
9	2.	11.	242.	20.	5035.	508254.
10	2.	11.	231.	19.	4810.	485528.
11	2.	10.	220.	18.	4585.	462862.
12	2.	10.	211.	18.	4387.	442855.
13	1.	10.	203.	17.	4223.	426229.
14	1.	9.	195.	16.	4059.	409728.
15	1.	9.	187.	16.	3892.	392857.
16	1.	9.	180.	15.	3735.	377011.
17	1.	8.	172.	14.	3589.	362242.
18	1.	8.	166.	14.	3446.	347781.
19	1.	7.	158.	13.	3280.	331201.

**************** R E G I O N   5   T O T A L S************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	51.	205.	2840.	237.	68267.	6042082.
1	64.	252.	3277.	273.	78322.	6908174.
2	64.	232.	2351.	196.	52593.	4700818.
3	42.	160.	1368.	114.	28582.	2592831.
4	26.	104.	968.	81.	20084.	1834328.
5	22.	87.	691.	56.	14371.	1308986.
6	20.	81.	567.	47.	11849.	1073617.
7	20.	79.	520.	43.	10693.	984850.
8	20.	79.	502.	42.	10526.	950603.
9	19.	77.	490.	41.	10269.	927194.
10	18.	73.	470.	39.	9844.	889368.
11	17.	69.	448.	37.	9386.	848078.
12	17.	67.	431.	36.	9031.	815709.
13	16.	65.	417.	35.	8739.	789255.
14	16.	62.	400.	33.	8397.	756507.
15	15.	60.	384.	32.	8048.	727087.
16	14.	58.	369.	31.	7739.	699107.
17	14.	55.	355.	30.	7436.	671738.
18	13.	53.	340.	28.	7132.	644260.
19	12.	48.	318.	26.	6659.	602003.

TABLE 22-D-2 (continued)

*************** NBTC SIMULATION MODEL ***************

......DAIRY MODEL...TESTING & WHOLE HERD VAC.74.5%........

*************** R E G I O N 6 T O T A L S***************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	14.	55.	524.	44.	12625.	1170281.
1	15.	69.	573.	48.	13766.	1278924.
2	14.	67.	591.	49.	14222.	1320743.
3	13.	61.	554.	46.	13280.	1238148.
4	11.	53.	486.	40.	11626.	1085249.
5	10.	47.	427.	36.	10220.	953722.
6	9.	42.	380.	32.	9104.	849207.
7	8.	39.	350.	29.	8395.	782345.
8	8.	38.	334.	28.	8012.	745855.
9	7.	35.	312.	26.	7482.	696925.
10	7.	31.	281.	23.	6741.	628542.
11	6.	28.	255.	21.	6103.	569027.
12	6.	27.	236.	20.	5656.	527005.
13	5.	25.	222.	19.	5333.	496664.
14	5.	23.	207.	17.	4955.	461655.
15	5.	22.	194.	16.	4646.	432820.
16	4.	21.	184.	15.	4419.	411488.
17	4.	20.	174.	14.	4172.	388539.
18	4.	18.	163.	14.	3911.	364318.
19	3.	17.	149.	12.	3565.	332275.

*************** R E G I O N 7 T O T A L S***************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	14.	54.	791.	66.	18977.	2197087.
1	6.	30.	541.	45.	12702.	1504141.
2	4.	21.	368.	31.	8697.	1022447.
3	3.	16.	296.	25.	7008.	823011.
4	3.	13.	242.	20.	5735.	673361.
5	2.	11.	202.	17.	4795.	562503.
6	2.	10.	173.	14.	4099.	480505.
7	2.	9.	151.	13.	3592.	420682.
8	2.	8.	136.	11.	3226.	377507.
9	2.	7.	123.	10.	2912.	340747.
10	1.	7.	110.	9.	2602.	304528.
11	1.	6.	98.	8.	2325.	272224.
12	1.	5.	88.	7.	2100.	245748.
13	1.	5.	81.	7.	1913.	223826.
14	1.	4.	73.	6.	1745.	204107.
15	1.	4.	67.	6.	1599.	187088.
16	1.	4.	62.	5.	1477.	172694.
17	1.	3.	58.	5.	1369.	160115.
18	1.	3.	54.	4.	1274.	148993.
19	1.	3.	49.	4.	1167.	136555.

TABLE

***************** NBTC SIMULATION MODEL *****************

......DAIRY MODEL...TESTING & WHOLE HERD VAC.74.5%........

***************** R E G I O N E T O T A L S**************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	4.	17.	432.	36.	10343.	1417862.
1	5.	21.	763.	64.	17799.	2503442.
2	6.	26.	695.	58.	16485.	2261511.
3	6.	27.	855.	71.	20148.	2607020.
4	6.	29.	961.	80.	22570.	3153967.
5	6.	30.	1005.	84.	23617.	3299586.
6	6.	31.	1051.	88.	24693.	3452284.
7	7.	31.	1086.	91.	25502.	3567183.
8	7.	32.	1110.	92.	26043.	3643588.
9	7.	32.	1128.	94.	26459.	3702472.
10	7.	32.	1141.	95.	26757.	3744833.
11	7.	32.	1149.	96.	26954.	3772875.
12	7.	32.	1155.	96.	27085.	3791433.
13	7.	32.	1158.	97.	27170.	3803503.
14	7.	32.	1161.	97.	27217.	3810253.
15	7.	32.	1161.	97.	27236.	3813126.
16	7.	32.	1161.	97.	27236.	3813183.
17	7.	32.	1161.	97.	27224.	3811478.
18	7.	32.	1160.	97.	27202.	3808508.
19	7.	32.	1159.	97.	27168.	3803773.

TABLE 22-B-3

**************** NBTC SIMULATION MODEL ****************

•••••• BEEF MODEL •••TESTING & WHOLE HERD VAC•90%••••••••

*************** U. S. T O T A L S********************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	20465.	15014.	452329.	111862.	80253744.
1	19888.	15545.	331467.	93059.	60614544.
2	18677.	12884.	231787.	58938.	39735648.
3	17969.	5904.	116808.	40276.	20796080.
4	17771.	2977.	62480.	32585.	12381553.
5	17324.	4369.	53975.	32850.	11138237.
6	17339.	3398.	50441.	34321.	10787039.
7	17370.	3162.	53514.	35350.	11282222.
8	16603.	3891.	64515.	33403.	12277211.
9	15411.	3845.	64108.	29727.	11677637.
10	14967.	2855.	49416.	28963.	9802683.
11	14667.	3145.	46264.	28735.	9383760.
12	14207.	3038.	47768.	27940.	9435402.
13	13308.	3262.	51185.	25418.	9496231.
14	12939.	2387.	41380.	24914.	8255043.
15	12526.	2794.	40682.	24259.	8073061.
16	11960.	2654.	41450.	22944.	7980960.
17	11527.	2364.	37775.	22154.	7435492.
18	10531.	2951.	41874.	19596.	7569100.
19	10012.	1958.	33516.	18394.	6423332.

*************** R E G I O N 1 T O T A L S************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	148.	150.	2593.	570.	457179.
1	150.	150.	2022.	565.	383536.
2	143.	143.	1992.	551.	377976.
3	134.	130.	1922.	526.	361977.
4	133.	107.	1628.	532.	322019.
5	126.	108.	1676.	504.	322647.
6	127.	95.	1478.	509.	296473.
7	126.	94.	1489.	511.	298062.
8	107.	113.	1755.	425.	318511.
9	84.	108.	1566.	331.	275843.
10	77.	79.	1127.	301.	210548.
11	72.	68.	1002.	284.	190164.
12	65.	66.	986.	255.	182351.
13	54.	66.	953.	212.	170082.
14	50.	52.	755.	197.	140201.
15	46.	48.	706.	182.	130922.
16	41.	46.	682.	163.	124215.
17	38.	42.	609.	150.	111814.
18	28.	45.	652.	109.	109545.
19	27.	32.	431.	103.	78827.

TABLE 22-B-3 (continued)

**************** NBTC SIMULATION MODEL ****************

•••••• BEEF MODEL •••TESTING & WHOLE HERD VAC•90%••••••••

**************** R E G I O N 2 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	38.	27.	324.	97.	61575.
1	43.	37.	430.	122.	81732.
2	42.	40.	499.	127.	91777.
3	42.	38.	495.	127.	90857.
4	43.	32.	424.	133.	82131.
5	42.	33.	456.	129.	85769.
6	44.	30.	413.	136.	81072.
7	45.	31.	434.	141.	84903.
8	40.	39.	530.	120.	93656.
9	34.	38.	473.	99.	82405.
10	32.	29.	366.	94.	66909.
11	31.	26.	335.	93.	62566.
12	29.	26.	347.	87.	63061.
13	26.	27.	344.	76.	60721.
14	24.	23.	288.	73.	52626.
15	23.	22.	280.	69.	50781.
16	21.	21.	273.	63.	48707.
17	20.	20.	249.	59.	44714.
18	16.	21.	260.	47.	44117.
19	15.	16.	196.	45.	34934.

**************** R E G I O N 3 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	5092.	3462.	79878.	20316.	14331217.
1	5000.	3637.	42126.	12084.	7340488.
2	5185.	1760.	16267.	9003.	3323542.
3	5183.	573.	8166.	6721.	1868962.
4	5206.	794.	5801.	7557.	1642220.
5	5128.	850.	7264.	7701.	1806442.
6	5144.	623.	6889.	7952.	1786807.
7	5163.	679.	7147.	8121.	1840318.
8	4993.	866.	8930.	7786.	2005300.
9	4676.	918.	10028.	6958.	2029799.
10	4571.	667.	6887.	6877.	1656506.
11	4495.	705.	6687.	6862.	1630154.
12	4382.	712.	7067.	6729.	1657194.
13	4147.	794.	8179.	6166.	1718044.
14	4049.	593.	6211.	6096.	1479545.
15	3938.	655.	6219.	5970.	1463950.
16	3769.	672.	6857.	5594.	1494645.
17	3650.	584.	5883.	5458.	1362787.
18	3359.	759.	7281.	4791.	1440029.
19	3221.	497.	5181.	4577.	1173690.

TABLE 22-B-3 (continued)

**************** NBTC SIMULATION MODEL ****************

...... BEEF MODEL ...TESTING & WHOLE HERD VAC.90%........

**************** R E G I O N 4 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	1149.	587.	31204.	8718.	5658272.
1	1133.	609.	24849.	7727.	4649237.
2	1124.	601.	24627.	7718.	4674376.
3	1023.	621.	19387.	4215.	3134109.
4	986.	255.	8209.	2571.	1356693.
5	935.	119.	4103.	1635.	692142.
6	918.	125.	2646.	1789.	535735.
7	903.	136.	3166.	1897.	607240.
8	863.	127.	3816.	1871.	679820.
9	813.	120.	3951.	1778.	683258.
10	783.	102.	3595.	1725.	635480.
11	759.	110.	3475.	1698.	618801.
12	731.	107.	3541.	1655.	621023.
13	693.	109.	3562.	1571.	612463.
14	668.	89.	3272.	1517.	572080.
15	642.	99.	3181.	1466.	555278.
16	614.	93.	3133.	1404.	541851.
17	588.	86.	2983.	1345.	516876.
18	546.	102.	3022.	1237.	507436.
19	521.	70.	2635.	1169.	453724.

**************** R E G I O N 5 T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	12872.	9396.	299015.	76189.	53320768.
1	12460.	9539.	234687.	67333.	43430528.
2	11170.	8836.	161239.	36505.	26577552.
3	10727.	3210.	61914.	24285.	11095268.
4	10605.	750.	26619.	17686.	5488561.
5	10421.	2318.	21543.	19368.	4995470.
6	10465.	1736.	23541.	20662.	5348805.
7	10522.	1493.	26184.	21515.	5779127.
8	10116.	1935.	32953.	20642.	6437105.
9	9414.	1906.	33921.	18503.	6279335.
10	9140.	1376.	26133.	18048.	5317214.
11	8968.	1700.	24130.	17982.	5076411.
12	8683.	1614.	25602.	17508.	5182385.
13	8122.	1750.	27974.	15928.	5260449.
14	7890.	1188.	22226.	15618.	4554453.
15	7630.	1555.	21907.	15216.	4459091.
16	7299.	1404.	22169.	14511.	4396365.
17	7032.	1246.	20456.	14033.	4144466.
18	6419.	1642.	23187.	12488.	4266166.
19	6073.	1018.	18928.	11623.	3668992.

TABLE 22-B-3 (continued)

**************** NBTC SIMULATION MODEL ****************

•••••• BEEF MODEL •••TESTING & WHOLE HERD VAC.90%••••••••

**************** R E G I O N   6   T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	GUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	735.	1050.	27961.	4003.	4527851.
1	721.	1149.	19842.	3643.	3416040.
2	671.	1109.	19994.	3545.	3435512.
3	568.	982.	18157.	3069.	3077131.
4	534.	756.	14090.	2903.	2490676.
5	444.	691.	13704.	2413.	2333868.
6	429.	577.	11057.	2315.	1960125.
7	414.	538.	10677.	2261.	1929891.
8	319.	611.	12194.	1774.	2006315.
9	254.	560.	10230.	1408.	1670593.
10	243.	440.	8118.	1334.	1372533.
11	229.	397.	7700.	1272.	1303562.
12	216.	381.	7411.	1206.	1251867.
13	178.	391.	7497.	1015.	1224849.
14	177.	330.	6209.	998.	1047596.
15	170.	312.	6118.	968.	1029640.
16	148.	318.	6167.	850.	1010841.
17	136.	294.	5561.	775.	913637.
18	112.	288.	5451.	644.	873266.
19	106.	246.	4506.	614.	738919.

**************** R E G I O N   7   T O T A L S*************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	GUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	407.	323.	10910.	1900.	1823039.
1	358.	400.	7100.	1510.	1242884.
2	319.	369.	6676.	1410.	1172652.
3	273.	324.	6269.	1258.	1085066.
4	245.	262.	5267.	1131.	924771.
5	210.	229.	4787.	972.	828830.
6	194.	194.	4027.	891.	711799.
7	179.	174.	3826.	838.	676446.
8	152.	180.	3915.	730.	668004.
9	124.	176.	3569.	605.	597429.
10	111.	146.	2897.	541.	495265.
11	101.	125.	2660.	501.	456169.
12	90.	117.	2534.	459.	431607.
13	79.	112.	2403.	415.	405720.
14	72.	101.	2186.	382.	370096.
15	66.	92.	2042.	355.	345675.
16	59.	87.	1943.	328.	327307.
17	54.	82.	1824.	304.	306803.
18	44.	82.	1805.	255.	294583.
19	42.	70.	1467.	239.	245921.

TABLE 22-B-3 (continued)

**************** NBTC SIMULATION MODEL ****************

...... BEEF MODEL ...TESTING & WHOLE HERD VAC.90%........

**************** R E G I O N & T O T A L S************

YEAR	UNDETECTED INF.HERDS	QUARNTD. HERDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS
0	24.	20.	446.	69.	73867.
1	23.	25.	409.	74.	70118.
2	22.	27.	493.	78.	82300.
3	20.	26.	498.	73.	82122.
4	19.	22.	442.	73.	74483.
5	18.	21.	441.	67.	73071.
6	18.	19.	391.	67.	66226.
7	18.	18.	391.	67.	66218.
8	15.	20.	423.	55.	68302.
9	13.	20.	370.	45.	56976.
10	12.	16.	293.	43.	48230.
11	12.	14.	276.	43.	45935.
12	11.	14.	280.	40.	45917.
13	10.	14.	272.	35.	43905.
14	10.	13.	233.	34.	38447.
15	10.	12.	229.	33.	37727.
16	9.	12.	226.	31.	36832.
17	9.	11.	210.	30.	34398.
18	7.	12.	214.	25.	33962.
19	7.	10.	173.	24.	28327.

TABLE 22-D-3

***************** NBTC SIMULATION MODEL *****************

•••••• DAIRY MODEL •••TESTING & WHOLE HERD VAC•90%•••••••••

***************** U. S. T O T A L S***********************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTC. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	209.	835.	16800.	1400.	403522.	38057984.
1	163.	794.	14032.	1169.	326861.	32185568.
2	137.	653.	9353.	779.	214609.	21473904.
3	99.	411.	5929.	494.	132462.	13824405.
4	69.	255.	4106.	342.	91596.	10016941.
5	54.	267.	3210.	268.	72552.	8189321.
6	48.	228.	2814.	235.	64281.	7415259.
7	46.	202.	2610.	218.	59983.	7014017.
8	45.	193.	2514.	210.	57930.	6823865.
9	43.	183.	2433.	203.	56051.	6649731.
10	39.	169.	2322.	194.	53463.	6401370.
11	37.	159.	2218.	185.	51034.	6162186.
12	35.	152.	2140.	178.	49226.	5980906.
13	34.	146.	2078.	173.	47787.	5836120.
14	32.	138.	2010.	167.	46215.	5676960.
15	31.	132.	1949.	162.	44806.	5536977.
16	30.	127.	1899.	158.	43680.	5422019.
17	28.	121.	1853.	154.	42619.	5314508.
18	27.	117.	1810.	151.	41619.	5213372.
19	26.	110.	1756.	146.	40379.	5088888.

***************** R E G I O N 1 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTC. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	26.	103.	1605.	134.	38659.	4047638.
1	18.	86.	1288.	107.	30618.	3246943.
2	15.	69.	1012.	84.	24142.	2552173.
3	12.	58.	833.	69.	19886.	2100898.
4	11.	50.	701.	58.	16751.	1768307.
5	10.	45.	616.	51.	14727.	1552601.
6	9.	41.	558.	47.	13360.	1407086.
7	8.	39.	522.	43.	12505.	1316048.
8	8.	38.	501.	42.	12013.	1263282.
9	8.	35.	469.	39.	11243.	1183151.
10	7.	30.	417.	35.	9984.	1052300.
11	6.	27.	367.	31.	8768.	924471.
12	5.	24.	328.	27.	7849.	826985.
13	5.	22.	297.	25.	7114.	749324.
14	4.	19.	265.	22.	6352.	669380.
15	4.	17.	238.	20.	5695.	600042.
16	3.	16.	216.	18.	5174.	544951.
17	3.	15.	197.	16.	4715.	496568.
18	3.	13.	180.	15.	4309.	453766.
19	2.	12.	159.	13.	3800.	400536.

TABLE 22-D-3 (continued)

****************** NBTC SIMULATION MODEL ******************

...... DAIRY MODEL ...TESTING & WHOLE HERD VAC.90%........

****************** R E G I O N 2 T O T A L S***************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	2.	10.	61.	5.	1474.	147641.
1	1.	6.	58.	5.	1393.	141481.
2	1.	5.	52.	4.	1225.	124963.
3	1.	4.	43.	4.	1031.	105246.
4	1.	4.	36.	3.	867.	88394.
5	1.	4.	32.	3.	761.	77489.
6	1.	3.	29.	2.	696.	70741.
7	1.	3.	28.	2.	664.	67374.
8	1.	3.	27.	2.	653.	66229.
9	1.	3.	26.	2.	628.	63737.
10	1.	3.	24.	2.	579.	58760.
11	1.	3.	22.	2.	530.	53852.
12	1.	2.	21.	2.	494.	50162.
13	1.	2.	19.	2.	464.	47099.
14	0.	2.	18.	1.	428.	43511.
15	0.	2.	17.	1.	397.	40310.
16	0.	2.	16.	1.	370.	37600.
17	0.	2.	14.	1.	345.	35017.
18	0.	2.	13.	1.	321.	32627.
19	0.	1.	12.	1.	289.	29336.

****************** R E G I O N 3 T O T A L S***************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	79.	314.	5207.	434.	125173.	10443844.
1	44.	218.	2567.	214.	56601.	4841349.
2	26.	102.	1097.	91.	22807.	1960813.
3	16.	35.	469.	39.	9361.	809030.
4	9.	46.	284.	24.	5673.	490893.
5	8.	36.	189.	16.	3783.	326105.
6	7.	27.	148.	12.	2980.	255452.
7	7.	25.	132.	11.	2653.	226867.
8	7.	25.	125.	10.	2520.	215143.
9	7.	24.	121.	10.	2440.	208272.
10	6.	23.	116.	10.	2335.	199359.
11	6.	22.	111.	9.	2235.	190823.
12	6.	22.	107.	9.	2168.	185017.
13	6.	21.	105.	9.	2114.	180407.
14	5.	20.	101.	8.	2040.	174129.
15	5.	20.	97.	8.	1964.	167669.
16	5.	19.	94.	8.	1903.	162430.
17	5.	18.	91.	8.	1838.	156885.
18	5.	18.	88.	7.	1772.	151273.
19	4.	17.	83.	7.	1684.	143826.

TABLE 22-D-3 (continued)

***************** NBTC SIMULATION MODEL *****************

•••••• DAIRY MODEL •••TESTING & WHOLE HERD VAC•90%••••••••

**************** R E G I O N 4 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	19.	77.	5341.	445.	127983.	12591564.
1	10.	71.	4966.	414.	115681.	11701157.
2	7.	71.	3187.	266.	74440.	7510474.
3	6.	50.	1510.	126.	33166.	3348222.
4	4.	33.	751.	63.	15508.	1577129.
5	2.	18.	346.	29.	6853.	701945.
6	1.	13.	218.	18.	4315.	442274.
7	1.	9.	146.	12.	2904.	296635.
8	1.	7.	115.	10.	2301.	233674.
9	1.	7.	104.	9.	2075.	210439.
10	1.	6.	97.	8.	1940.	196605.
11	1.	6.	91.	8.	1831.	185598.
12	1.	6.	87.	7.	1746.	176847.
13	1.	5.	84.	7.	1675.	169654.
14	1.	5.	80.	7.	1605.	162618.
15	1.	5.	77.	6.	1535.	155490.
16	1.	5.	73.	6.	1470.	148875.
17	1.	5.	70.	6.	1409.	142692.
18	1.	4.	67.	6.	1349.	136652.
19	1.	4.	64.	5.	1283.	130036.

**************** R E G I O N 5 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	51.	205.	2840.	237.	68287.	6042082.
1	64.	292.	3277.	273.	78322.	6968174.
2	64.	292.	2351.	196.	52593.	4700818.
3	42.	160.	1368.	114.	28582.	2592831.
4	25.	29.	649.	54.	12964.	1168370.
5	15.	79.	407.	34.	8110.	744910.
6	13.	63.	281.	23.	5631.	514899.
7	13.	49.	232.	19.	4671.	424668.
8	13.	47.	216.	18.	4347.	394374.
9	12.	45.	207.	17.	4174.	378479.
10	12.	43.	197.	16.	3972.	360244.
11	11.	41.	187.	16.	3779.	342774.
12	11.	40.	181.	15.	3655.	331345.
13	11.	39.	176.	15.	3550.	321846.
14	10.	37.	169.	14.	3403.	308619.
15	10.	36.	161.	13.	3250.	294802.
16	9.	35.	155.	13.	3136.	284300.
17	9.	33.	150.	12.	3019.	273767.
18	9.	32.	144.	12.	2901.	263116.
19	8.	30.	136.	11.	2748.	249297.

TABLE 22-D-3 (continued)

**************** NBTC SIMULATION MODEL ****************

...... DAIRY MODEL ...TESTING & WHOLE HERD VAC.90%........

**************** R E G I O N 6 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	14.	55.	524.	44.	12625.	1170281.
1	15.	69.	573.	48.	13766.	1278924.
2	14.	67.	591.	49.	14222.	1320743.
3	13.	61.	554.	46.	13280.	1238148.
4	11.	52.	482.	40.	11530.	1076522.
5	9.	45.	415.	35.	9931.	927248.
6	8.	39.	359.	30.	8579.	800795.
7	7.	35.	319.	27.	7627.	711442.
8	7.	33.	293.	24.	7025.	654626.
9	6.	30.	266.	22.	6369.	593700.
10	5.	26.	233.	19.	5587.	521356.
11	5.	23.	206.	17.	4935.	460373.
12	4.	21.	187.	16.	4478.	417462.
13	4.	20.	173.	14.	4154.	387017.
14	4.	18.	159.	13.	3804.	354517.
15	4.	17.	147.	12.	3517.	327732.
16	3.	16.	138.	11.	3307.	307961.
17	3.	15.	129.	11.	3094.	288175.
18	3.	14.	120.	10.	2881.	268425.
19	3.	12.	109.	9.	2620.	244181.

**************** R E G I O N 7 T O T A L S*************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	14.	54.	791.	66.	18977.	2197087.
1	6.	30.	541.	45.	12702.	1504141.
2	4.	21.	368.	31.	8697.	1022447.
3	3.	16.	296.	25.	7008.	823011.
4	3.	13.	242.	20.	5735.	673361.
5	2.	11.	202.	17.	4782.	560931.
6	2.	10.	171.	14.	4055.	475398.
7	2.	9.	148.	12.	3508.	411066.
8	2.	8.	131.	11.	3104.	363405.
9	1.	7.	116.	10.	2759.	323007.
10	1.	6.	102.	9.	2428.	284346.
11	1.	5.	90.	8.	2137.	250334.
12	1.	5.	80.	7.	1901.	222566.
13	1.	4.	72.	6.	1707.	199785.
14	1.	4.	65.	5.	1535.	179663.
15	1.	3.	58.	5.	1388.	162459.
16	1.	3.	53.	4.	1265.	148034.
17	1.	3.	49.	4.	1159.	135656.
18	1.	3.	45.	4.	1068.	124926.
19	1.	2.	41.	3.	971.	113675.

TABLE 22-D-3 (continued)

***************** NBTC SIMULATION MODEL *****************

•••••• DAIRY MODEL •••TESTING & WHOLE HERD VAC•90%••••••••

**************** R E G I O N & T O T A L S************

YR	UND. INF.HRDS	QUARNTD. HRDS	QUARNTD. INF.COWS	INFECTED COWS	CALF LOSS POUNDS	MILK LOSS POUNDS
0	4.	17.	432.	36.	10343.	1417862.
1	5.	21.	763.	64.	17799.	2503442.
2	6.	26.	695.	58.	16485.	2281511.
3	6.	27.	855.	71.	20148.	2807020.
4	6.	29.	961.	80.	22570.	3153967.
5	6.	30.	1005.	84.	23605.	3298096.
6	6.	30.	1050.	88.	24666.	3448616.
7	7.	31.	1084.	90.	25450.	3559920.
8	7.	31.	1107.	92.	25968.	3633134.
9	7.	32.	1124.	94.	26362.	3688951.
10	7.	32.	1136.	95.	26639.	3728383.
11	7.	32.	1143.	95.	26819.	3753963.
12	7.	32.	1148.	96.	26935.	3770522.
13	7.	32.	1152.	96.	27009.	3780988.
14	7.	32.	1153.	96.	27047.	3786524.
15	7.	32.	1154.	96.	27060.	3788474.
16	7.	32.	1154.	96.	27055.	3787870.
17	7.	32.	1153.	96.	27040.	3785749.
18	7.	32.	1152.	96.	27017.	3782589.
19	7.	32.	1151.	96.	26984.	3778001.

level of vaccination, annual beef losses were still moving downward in the last year of the program.

In comparing levels of infection and annual beef losses for the U. S. between the whole-herd and calfhood vaccination options, two observations stand out. First, levels of infection and losses move downward somewhat more rapidly under the whole-herd vaccination program than under calfhood vaccination. This results from two factors: (1) Whole-herd vaccination permits producers to attain a high-level of herd protection in a much shorter period than with calfhood vaccination; and (2) Herd testing prior to whole-herd vaccination not only identified numerous infected animals, but also facilitated their removal from the herd, thereby reducing disease spread.

The second observation is that the levels of infection and annual losses at the end of the 20-year period were lower for calfhood than for whole-herd vaccination. The primary reason for this relationship is that the whole-herd vaccination was applied only in Regions 3, 4, and 5, whereas calfhood vaccination was applied in Regions 3, 4, 5, 6, and 7.

Data showing the levels of both herd and cow infection and physical losses for dairy herds under program option 4 are outlined Tables 22-D-1, 22-D-2 and 22-D-3 for the low, medium and high levels of infection, respectively. As noted above for beef herds, reductions in brucellosis infection (in terms of numbers of infected cows) and in physical losses are strongly and positively associated with the level of herd vaccination. Even so, annual milk losses were reduced 77 percent between year 0 and year 19 under the low level of herd vaccination. We must keep in mind, however, that an important part of this early reduction is attributable to herd testing prior to whole-herd vaccination.

The impact of the whole-herd vaccination program in the high prevalence regions is quite dramatic. For example, annual beef losses were reduced by approximately 93 percent between year 0 and year 19 under the high level of herd vaccination for Regions 3, 4, and 5. Dairy loss reductions in those regions were even more dramatic.

5. <u>No Program</u>

The "No Program" option was designed to demonstrate what the economic impacts might be if all aspects of the state-federal brucellosis control program were to be discontinued. The physical loss coefficients for this model were derived from the APHIS Brucellosis Model reviewed in Chapter I. However, because the APHIS model was based on only five regions (instead of the eight used in our simulation model), we were not able to structure regional simulations, but focussed only on national projections. Moreover, because the APHIS model assumed an initial starting point from a low level of infection, while our model began with an estimate of the level of infection prevailing in 1976, we eliminated year 0 from our estimates of losses under "No Program."

A listing of the physical losses of milk, dairy calves and weaned beef calves for the U. S. are outlined by years in Table 23. Beef

Table 23. Projected Physical Losses from Brucellosis for Beef and Dairy Herds under "No Program", U.S.

Year	Weaner Calf Losses (1000 lbs)	Dairy Calf Losses (1000 lbs)	Milk Losses (1000 lbs)
1	97,983	2,412	76,274
2	163,093	5,011	158,149
3	264,657	10,805	349,617
4	408,222	18,029	605,162
5	568,264	24,580	860,092
6	733,534	29,441	1,077,382
7	884,896	32,962	1,258,484
8	1,014,201	35,480	1,404,445
9	1,119,546	37,742	1,532,389
10	1,202,099	40,197	1,657,951
11	1,264,746	43,381	1,808,228
12	1,311,205	46,494	1,943,289
13	1,344,600	50,439	2,114,037
14	1,369,256	54,852	2,305,429
15	1,385,128	59,654	2,515,078
16	1,397,029	64,661	2,738,659
17	1,406,075	69,701	2,969,767
18	1,411,329	74,571	3,199,868
19	1,415,500	79,034	3,419,361

losses are projected to increase 14-fold during the 19-year period, to an annual level of 1.4 billion pounds in year 19. Dairy losses were projected to increase at a rate approximately three times the rate for beef. The primary reason for this difference is the increased effectiveness of the BRT over the MCI as surveillance tools, which resulted in dairy herds having much lower average levels of infection than beef herds in year 0. Although there is little likelihood that all state and federal brucellosis programs will be eliminated, these data given an indication of the serious physical losses that could result if such events were to occur.

Economic Losses to Primary Producers--An Illustration

The first impact of brucellosis, of course, is on those primary producers (cow-calf operators and dairymen) whose herds become infected. These producers experience losses in the form of:

(1) lowered sales of: (a) weaned calves (for beef producers), and (b) bull and surplus heifer calves and milk (for dairymen); and

(2) losses incurred from forced culling of infected productive beef or dairy cows.

It may be instructive to examine the magnitude of these losses for a single year. We selected 1976 since it was the first year of modeling; hence, the losses are about the same for each program alternative. The estimates in Table 24 relate to the base program, however.

The loss incurred from forced culling of infected animals represents the difference between the value of the animal in the beef or dairy herd and its salvage value (whatever federal and state indemnity payments are received have not been included).

Total losses to primary producers whose herds were infected with brucellosis in 1976 are summarized in Table 24.

Table 24. Estimated Total Economic Losses by Producers from Brucellosis 1976.

Type of Loss	Infected Beef Herds	Infected Dairy Herds
	($)	($)
Calf losses	24,597,773	132,194
Milk losses	-	3,474,694
Cull losses	16,798,837	3,200,114
Total economic losses	41,396,610	6,807,002

Thus, the combined economic losses to U. S. cattlemen and dairymen whose herds were infected with brucellosis were estimated at 48.2 million dollars in 1976.

There are a number of reasons why these static losses to primary producers can not be used as a measure of the total economic loss to society. First, while the individual producer with infected cattle might experience a serious loss, producers who do not experience infection are likely made better off because lower levels of total beef and milk production will tend to increase prices. Second, if beef or milk prices are increased, consumers are made worse off. Moreover, while the producer who must sell his high producing dairy or beef cow for slaughter will experience a culling loss, some other producer will reap a windfall gain from selling as a herd replacement a bred heifer that would otherwise have gone to slaughter.

Thus, as interesting as it might be to identify losses to producers with infected herds, some of these losses are often offset by gains to other producers or consumers. Hence, a benefit/cost analysis of alternative programs measured at the primary producer level only could lead to policy action which might not be advantageous to the broader economic interests. Therefore, we must use an aggregate approach and estimate the impact of the disease on the total economy.

Economic Benefits Associated with Program Alternatives

In estimating national economic benefits from various control programs, the differences in the annual physical losses of beef and milk associated with each program alternative were measured from the levels of losses projected for the "base program" alternative. These annual differences in losses were then used as "supply shifters" in the production of beef and milk to determine new equilibrium prices, using a modification of the USDA "Cross-commodity Feed-Grain-Livestock-Wheat Model".[1]

We are now in position to estimate "net social gain" or benefits in terms of changes in consumers' and producers' surpluses. Although debate continues in the literature over the use of consumers' and producers' surpluses as estimates of social gains, most economists agree that this technique is useful in assessing short-run benefits and costs of public policies or programs. Although this study considers a 20-year period, producer and consumer adjustments are in terms of successive shifts in, and movement along, short-run supply and demand functions. Hence, estimates of both producers' and consumers' surpluses are valid components of the economic value of alternative brucellosis control programs to society.

The logic of consumers' and producers' surplus due to shifts in the supply function for beef (for example) is illustrated graphically in Figure 3. Let line DD represent the demand curve for beef and line SS represent the supply curve for beef under the basic program. Then assume that the 10-year accelerated eradication program is initiated, resulting in an increased supply schedule, SS_1. Because prices would

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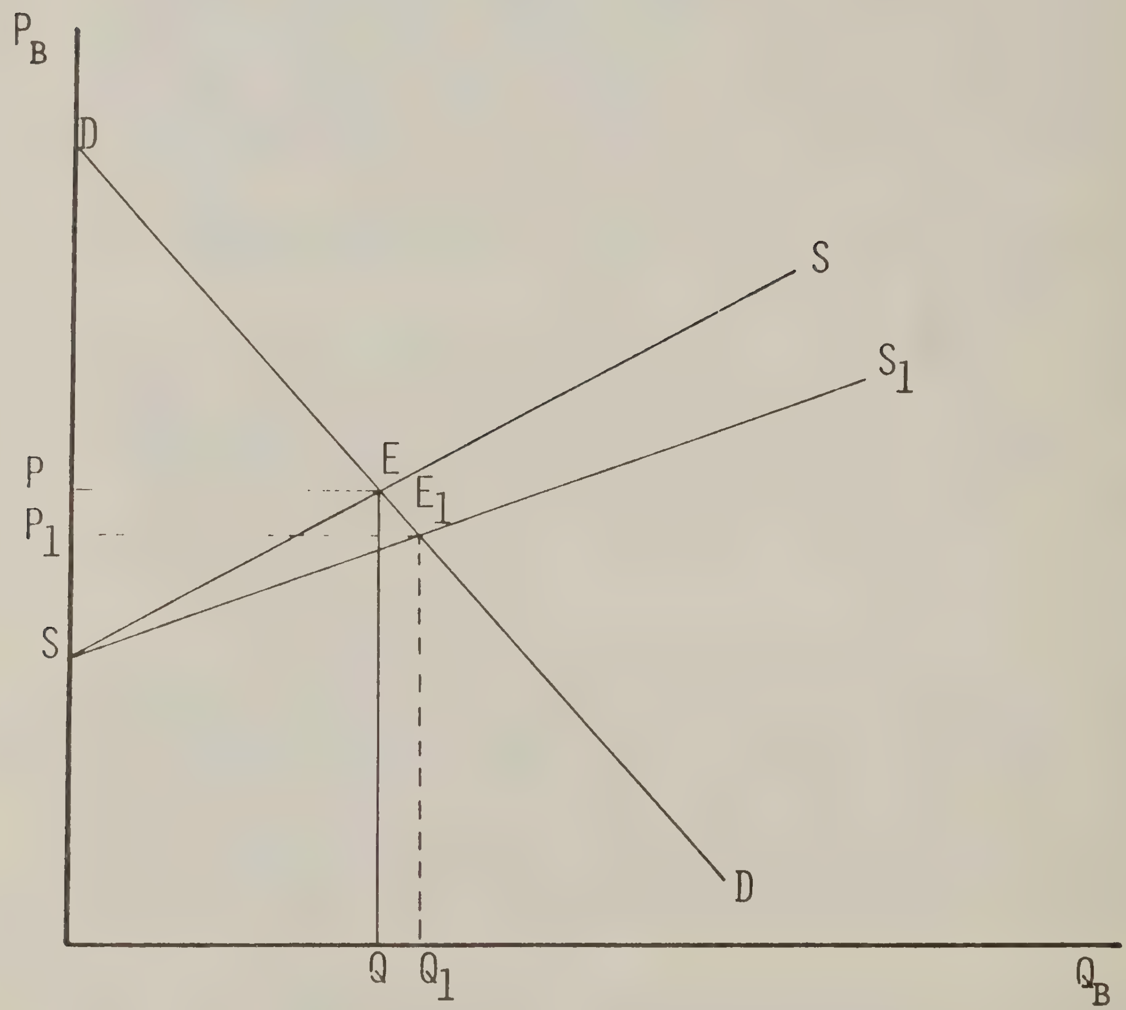
[1]For a discussion of the economic model used, see Annex 8. We are indebted to Drs. L. D. Tiegen, C. Carmen and the Forecast Support Unit, CED, USDA for permitting use of their model.

Figure 3. A Graphic Illustration of Consumers' and Producers' Surplus.



Where:

DD: Demand curve for beef

SS: Supply curve for beef under "Base Program" for brucellosis control

SS_1: Supply curve for beef under "Accelerated Brucellosis Eradication Program"

The change in Consumer surplus = area PEE_1P_1 .

The change in Producer surplus = difference between areas PSE and P_1SE_1.

be lowered from P to P_1, consumers would increase beef purchases from Q to Q_1. As a result, consumers' surplus would be increased by the area PEE_1P_1. The change in producers' surplus is represented by the difference between areas PSE and P_1E_1.

Comparison of net economic benefits from the several alternative brucellosis programs is outlined below for each program alternative by years, beginning in year 1. Annual producers' and consumers' surpluses are estimated for each program alternative, and these two variables are combined to obtain total surpluses, which is our measure of economic benefits. As a general rule, changes in the programs which reduce physical losses, increase supplies of beef and milk and exert downward pressures on prices. As a consequence, consumers are made better off and producers' surpluses are usually reduced. Conversely, decreases in supplies of beef and milk will decrease consumer surpluses and will usually increase producers' surpluses. Whether total surplus (producers' plus consumers' surpluses) is, on balance, positive or negative depends on the nature of the demand and supply functions for the commodities in question.

Annual projections of producers', consumers' and total surpluses are listed for each program alternative in Tables 25 through 27. Comparison of the total surplus columns for the various programs shows that all variations of Option 2 (the accelerated program), Option 3 (calf herd vaccination) and Option 4 (whole herd vaccination in high prevelance regions) yield positive economic benefits when compared to the base program. It remains to be seen whether or not these benefits are greater than the total costs associated with the programs. Assessing program costs is the topic of Chapter V.

In Table 28, the economic benefits of shifting from the base program to a no program option are outlined. Although producers' surpluses were strongly positive in every year under the assumption of this program, consumers would be made considerably worse off, so that on balance, economic benefits were strongly negative every year of the program.

TABLE 25.1

ACCELERATED PROGRAM #1 VS. BASE PROGRAM--U.S. TOTAL

YEAR	PRODUCER SURPLUS	CONSUMER SURPLUS	TOTAL SURPLUS
1	1926852.	-8230133.	-6303281.
2	-2685801.	8230119.	5544318.
3	-7829494.	22780390.	14950895.
4	1314558.	-12238000.	-10923442.
5	-28544444.	98159146.	69614702.
6	-50148259.	163314383.	113166124.
7	-64544425.	182655798.	118111373.
8	-83774666.	220934289.	137159623.
9	-74965833.	135780073.	60814241.
10	-60223351.	44853058.	-15370293.
11	-65964702.	54429744.	-11534957.
12	-78583035.	101679602.	23096567.
13	-106988763.	232312243.	125323480.
14	-118804019.	283836485.	165032466.
15	-132111253.	272168294.	140057042.
16	-112871828.	199845295.	86973467.
17	-98588429.	91940249.	-6648179.
18	-99308688.	48224321.	-51084368.
19	-113610887.	29248424.	-84362463.

TABLE 25.2

ACCELERATED PROGRAM #2 VS. BASE PROGRAM--U.S. TOTAL

YEAR	PRODUCER SURPLUS	CONSUMER SURPLUS	TOTAL SURPLUS
1	1926852.	-8230133.	-6303281.
2	-2685801.	8230119.	5544318.
3	-7829494.	22780390.	14950895.
4	1314558.	-12238000.	-10923442.
5	-28544444.	98159146.	69614702.
6	-50148259.	163314383.	113166124.
7	-64544425.	182655798.	118111373.
8	-83774666.	220934289.	137159623.
9	-74965833.	135780073.	60814241.
10	-60925475.	45621652.	-15303823.
11	-66798566.	58050348.	-8748218.
12	-71516902.	76358635.	4841734.
13	-91488983.	178437762.	86948779.
14	-100170415.	231366926.	131196511.
15	-110791270.	225909852.	115118582.
16	-91157997.	165579997.	74422000.
17	-75805443.	67110992.	-8694451.
18	-71540698.	14587127.	-56953571.
19	-81530569.	-4693010.	-86223579.

TABLE 26.1

CALFHOOD VACCINATION 39.5% VS. BASE PROGRAM--U.S. TOTAL

YEAR	PRODUCER SURPLUS	CONSUMER SURPLUS	TOTAL SURPLUS
1	0.	0.	0.
2	0.	0.	0.
3	-74568816.	230949947.	156381131.
4	-69320464.	179277993.	109957529.
5	-49732876.	84123777.	34390901.
6	-43491373.	55780238.	12288865.
7	-34320948.	-10883075.	-45204022.
8	-61523843.	104127748.	42603905.
9	-81808986.	198529244.	116720258.
10	-76249362.	174481319.	98231957.
11	-80375525.	180129742.	99754218.
12	-71600177.	108129194.	36529018.
13	-67021118.	49108115.	-17913003.
14	-69527369.	52943464.	-16583905.
15	-99689493.	146056386.	46366893.
16	-101232945.	220591787.	119358841.
17	-97356696.	211557438.	114200742.
18	-94966565.	164947640.	69981074.
19	-92439680.	40441703.	-51997977.

TABLE 26.2

CALFHOOD VACCINATION 74.5% VS. BASE PROGRAM--U.S. TOTAL

YEAR	PRODUCER SURPLUS	CONSUMER SURPLUS	TOTAL SURPLUS
1	0.	0.	0.
2	0.	0.	0.
3	-74568816.	230949947.	156381131.
4	-104279032.	299638535.	195359502.
5	-108827450.	273287219.	164459769.
6	-80746992.	133393512.	52646521.
7	-62758645.	17152654.	-45605990.
8	-90751536.	121380673.	30629137.
9	-106680908.	196775482.	90094574.
10	-107881090.	225447816.	117566726.
11	-118133389.	275615957.	157482568.
12	-112348290.	220844026.	108495735.
13	-104927852.	141693310.	36765459.
14	-97090571.	85894222.	-11196349.
15	-127310822.	143015559.	15704737.
16	-124368593.	222369333.	98000740.
17	-121799294.	238803672.	117004378.
18	-122471883.	224799164.	102327281.
19	-126384842.	114557467.	-11827375.

TABLE 26.3

CALFHOOD VACCINATION 90.0% VS. BASE PROGRAM--U.S. TOTAL

YEAR	PRODUCER SURPLUS	CONSUMER SURPLUS	TOTAL SURPLUS
1	0.	0.	0.
2	0.	0.	0.
3	-74568816.	230949947.	156381131.
4	-104279032.	299638535.	195359502.
5	-108827450.	273287219.	164459769.
6	-94225536.	187342863.	93117327.
7	-83061456.	87281650.	4220194.
8	-107830560.	162161178.	54330618.
9	-119501908.	212210153.	92708245.
10	-113023558.	203371306.	90347747.
11	-122683155.	253712206.	131029051.
12	-122487378.	233997363.	111509985.
13	-122530149.	194595346.	72065196.
14	-115782338.	149461790.	33679453.
15	-144398458.	187831095.	43432637.
16	-134092397.	230081445.	95989048.
17	-127472624.	216840750.	89368125.
18	-128949579.	202353167.	73403588.
19	-136149250.	113353015.	-22796235.

ABLE 27.1

WHOLE HERD VACCINATION 39.5% VS. BASE PROGRAM--U.S. TOTAL

YEAR	PRODUCER SURPLUS	CONSUMER SURPLUS	TOTAL SURPLUS
1	-9817130.	30792096.	20974965.
2	-53771216.	142975741.	89204525.
3	-88637357.	217647990.	129010633.
4	-68986723.	123092120.	54105397.
5	-49218136.	42933758.	-6284378.
6	-34803786.	-14843686.	-49647472.
7	-49740697.	48609930.	-1130767.
8	-88464512.	218965972.	130501460.
9	-99544909.	263598515.	164053606.
10	-83947511.	186038936.	102091426.
11	-74308222.	112841427.	38533205.
12	-59122210.	4380248.	-54741962.
13	-64942981.	14050040.	-50892941.
14	-81551545.	103653385.	22101840.
15	-119139629.	240507561.	121367932.
16	-114605850.	290184662.	175578812.
17	-100896933.	214209019.	113312087.
18	-90670523.	100577441.	9906918.
19	-85480795.	-58082404.	-143563198.

TABLE 27.2

WHOLE HERD VACCINATION 74.5% VS. BASE PROGRAM--U.S. TOTAL

YEAR	PRODUCER SURPLUS	CONSUMER SURPLUS	TOTAL SURPLUS
1	-9817130.	30792096.	20974965.
2	-58844113.	159024082.	100179970.
3	-112344751.	285160475.	172815724.
4	-95922042.	193524371.	97602328.
5	-73182552.	92525262.	19342710.
6	-48674772.	-9565504.	-58240276.
7	-61347804.	40006967.	-21340837.
8	-111580135.	259679993.	148099858.
9	-123895512.	313485046.	189589534.
10	-107124528.	239793049.	132668521.
11	-95709573.	158942082.	63232509.
12	-75613302.	20925166.	-54688136.
13	-78046224.	9153379.	-68892845.
14	-94480256.	104647145.	10166889.
15	-139036615.	266510925.	127474310.
16	-133496156.	334027782.	200531625.
17	-118109091.	254794830.	136685739.
18	-104453958.	124649411.	20195453.
19	-99237337.	-54223933.	-153461270.

TABLE 27.3

WHOLE HERD VACCINATION 90.0% VS. BASE PROGRAM--U.S. TOTAL

YEAR	PRODUCER SURPLUS	CONSUMER SURPLUS	TOTAL SURPLUS
1	-9817130.	30792096.	20974965.
2	-58844113.	159024082.	100179970.
3	-114554496.	293702910.	179148414.
4	-106378978.	227988706.	121609728.
5	-86343853.	130682635.	44338783.
6	-58387363.	8727462.	-49659901.
7	-68371209.	45797109.	-22574100.
8	-118654790.	262561603.	143906813.
9	-132266549.	322939263.	190672714.
10	-117063469.	258865891.	141802422.
11	-107119128.	187731170.	80612042.
12	-86980802.	51245162.	-35735640.
13	-87743346.	26388492.	-61354854.
14	-103306819.	110684371.	7377552.
15	-148995457.	272264511.	123269054.
16	-142191782.	342570252.	200378470.
17	-127574245.	274039248.	146465003.
18	-114968278.	147351561.	32383284.
19	-108839785.	-45391204.	-154230989.

TABLE 28

NO PROGRAM VS. BASE PROGRAM--U.S. TOTAL

YEAR	PRODUCER SURPLUS	CONSUMER SURPLUS	TOTAL SURPLUS
1	70969708.	-247084822.	-176115113.
2	243616478.	-678991400.	-435374923.
3	491859761.	-1354652841.	-862793080.
4	715426840.	-2053082437.	-1337655597.
5	866048824.	-2429528683.	-1563479860.
6	987346166.	-2614684167.	-1627338002.
7	1136403037.	-2640145076.	-1503742039.
8	1305060892.	-2740381704.	-1435320812.
9	1486694132.	-3054624405.	-1567930273.
10	1637536163.	-3279307416.	-1641771253.
11	1769381499.	-3266314294.	-1496932795.
12	1817938535.	-3197432007.	-1379493472.
13	1947013058.	-3363376018.	-1416362960.
14	2229120479.	-4003455157.	-1774334678.
15	2372633186.	-4472706132.	-2100072946.
16	2409839382.	-4404878242.	-1995038860.
17	2423656775.	-3899475193.	-1475818417.
18	2416047812.	-3091217663.	-675169851.
19	2521743324.	-2668603828.	-146860504.

CHAPTER V: ESTIMATES OF COSTS

For purposes of benefit/cost analysis, we identify as costs those expenditures incurred by federal and state governments relating to brucellosis plus estimates of costs incurred by private operators due to bovine brucellosis. No attempt is made in this analysis to subtract out of total federal and state expenditures those small portions spent on non-bovine species.

State and Federal Expenditures

During the 20-year period 1956-75 state and federal expenditures totaled $450.6 million and $415.9 million, respectively. These costs are shown by years in Table 29. Federal expenditures for 1976 were reported at $36.8 million, while state costs were reported at $38.8 million.

Base figures used in projecting federal expenditures came from projections made by APHIS, USDA for their 10-year Accelerated Eradication Program. Modifications from these costs were made to account for differences in program services and levels of infection from those assumed in the APHIS projection. A detailed description of the relevant cost components follows.[1]

1. Primary Surveillance

   a. MCI - All activities associated with the Market Cattle Testing Program. This includes collection of samples at slaughter, tracing all positive samples to the farm of origin, and the initial test of each suspicious herd. These costs are related positively to the number of cattle moving to market and to the number of positive reactors identified.

   b. BRT - all activities associated with collecting brucellosis ring test samples, tracing to the appropriate herd, and conducting the initial herd test. These costs are positively related to the number of dairy herds under surveillance and the number of positive or suspicious tests detected.

2. Secondary Surveillance

   a. Area testing of high-incidence areas - All activities associated with contacting owners to line up herds for testing and the initial test of all herds within a geographic area designated for testing because of an excessive herd infection rate. These costs were projected by APHIS, USDA to represent their projected area testing plans for states in Regions 3, 4, and 5 of this study.

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[1] This description enlarges on information supplied by Dr. Billy G. Johnson, Chief Staff Veterinarian, National Brucellosis Eradication Program, APHIS, USDA, Washington, D.C.

Table 28. Federal and State Brucellosis Program Costs--1955 to 1975

	Obligations in Actual Dollars		
Year	Federal	State and Cooperators	Total
1956	$ 20,185,600	$ 15,730,479	$ 35,916,079
1957	20,999,582	15,841,562	38,841,144
1958	22,251,776	16,705,945	38,957,721
1959	20,229,850	17,064,961	37,294,811
1960	16,643,030	14,084,256	30,728,188
1961	19,418,575	19,888,256	39,306,831
1962	19,291,168	20,439,928	39,731,096
1963	19,369,109	21,264,847	40,633,956
1964	19,510,268	22,792,830	42,303,098
1965	20,493,646	23,053,322	43,546,468
1966	20,585,003	23,268,632	43,853,635
1967	21,043,409	24,045,848	45,089,257
1968	21,664,220	24,800,640	46,464,860
1969	20,515,435	24,050,909	44,606,344
1970	21,707,173	24,977,053	46,684,226
1971	16,631,586	25,169,645	41,801,231
1972	18,538,556	25,968,802	44,507,358
1973	21,460,800	27,566,444	49,027,244
1974	24,570,758	29,653,750	54,224,508
1975	30,779,977	34,226,047	65,006,024
Total	415,890,421	450,634,158	866,524,579

b. Adjacent and contact herd testing - All activities associated with contacting owners whose cattle are on farms adjacent to affected farms or whose cattle have been in contact with infected cattle, and with conducting the initial test on these farms. These costs are an outgrowth of the MCI and BRT tests, with a carry-over into years beyond the completion of area testing.

c. Epidemiology - Review of herd histories of all affected farms to determine the source of the infection and to determine all animal movements into and out of the affected farms. Also, includes activities associated with tracing movements to and from affected farms. The level of cost category "b" and "c" is largely a function of the number of positive tests detected through all types of surveillance.

d. Diagnostic Investigations - Includes field investigations of herds from which diagnostic specimens that may be suspicious of brucellosis have been submitted to laboratories or reports of possible affected herds as reported by county agents, etc.

e. Testing at markets - Primarily associated with paying veterinary practitioners to blood test all slaughter cattle being sold through livestock markets in certain high-incidence states. This "first point of concentration" testing is tied closely to area testing as a part of the "accelerated eradication program". It is expected to continue after area testing until the level of infection is brought down to a "target" level.

3. Elimination of Infected Herds. The level of these costs are largely a function of the number of infected herds, the level of infection within herds and the clean up rate.

a. Retests of affected herds - This includes the expenses of conducting all retests on affected herds other than the initial test.

b. Tagging and branding reactors - Includes all activities associated with tagging and branding reactors found based on farm tests including the completion of all appropriate permits for movements and indemnity requests.

c. Issuing permits and "S" branding exposed cattle - This includes placing a hot "S" brand on exposed cattle which are to be sold for slaughter and the issuance of the necessary permits for movement.

d. Indemnity - Costs are influenced not only by the number of animals sent to slaughter, but by the per-head indemnity paid by the federal government. The indemnity paid by the state is a separate cost.

(1) Regular - Indemnity for reactors found as a result of herd tests.

(2) Depopulation - Indemnity for exposed cattle in affected herds when the entire herd is being depopulated.

e. Appraising and identification in herd depopulations - This includes appraising animals as required by the Code of Federal Regulations and placing identification tags and the hot "B" brand on all exposed cattle in herds that are being depopulated.

4. Vaccination. This cost is determined by the number of herds and animals to be vaccinated.

   a. Calfhood - This item includes the actual expenses involved with the administration of vaccine. The expenses include the cost of administration done by regulatory officials and fee-basis payments to veterinary practitioners.

   b. Adult vaccination - This includes the cost of the initial complete herd test, identification of reactors, administration of vaccine to all adult-negative animals in the herd, and follow-up administration of vaccine to replacement cattle.

5. Regulation Enforcement and Inspection - This includes activities associated with proper identification of animals moving in commerce inspection of animals at livestock markets, and investigation of improper or illegal movements of animals. Largely, this cost is a function of numbers of cattle moving in the market and the level of concern over infection spread.

6. Laboratory and Recordkeeping - These costs are mostly fixed costs, but increase slightly with number of infected herds and cattle.

   a. Laboratory - Includes all costs associated with conducting brucellosis tests on blood and milk samples at state and federal laboratories.

   b. Recordkeeping - Primarily involved with contracts with individual states to maintain records in the brucellosis program.

7. Supplies, Equipment, Rental, etc. - This includes the purchase of supplies such as eartags, backtags, bleeding tubes, brucella antigen, brucella vaccines, and payments to General Services Administration (GSA) for building rental. Again, some of these costs are fixed, while others vary directly with the number of tests, number of vaccinations, etc.

8. Field Trials - This includes costs associated with either activities conducted by APHIS personnel or support of universities or private industry conducting field trials associated with the brucellosis

eradication program. These costs are expected to increase from the 1976 level and remain at a higher level until the disease has been eradicated from cattle in all regions of the U.S.

9. Overhead - Includes overhead cost to support the brucellosis share of the expenses. This includes the Administrator's office, Deputy Administrator's office, the Hyattesville office, including the Regional Directors and the Brucellosis Staff and the area offices.

Projected federal expenditures

Projected annual federal expenditures will vary, of course, by type of federal program. A summary of these projections is presented in Table 30 by years for a 20 year period starting in 1976 for the various program alternatives.

Federal costs for the base program option were projected to remain constant at the 1976 level of $36.8 million, in constant (1976) dollar terms. Under the accelerated program options, however, federal costs were projected to move up sharply to cover the cost of first point of concentration testing and area testing during the period when these activities were initiated in the model. Recall from discussions in Chapter IV that first point of concentration began in the model one year before area testing was initiated in each region. Area testing was scheduled as follows for each of the three applicable regions: Region 3 in years 2 through 4; Region 5 in years 4 through 6; and Region 6 in years 6 through 8. Associated with increased costs for surveillance and detection, of course, are increased costs for indemnities.

The costs for option 1 and option 2 of the accelerated program were identical through model year 9. Starting in year 10, however, option 1 became slightly more costly due to two factors which were not entirely offsetting. First, increased costs for educational programs were assumed to be necessary in order to maintain a high level of program performance after area testing was completed. Second, the decreased levels of infection achieved under option 1 lowered federal program costs for surveillance and indemnities. It was assumed that, on balance, option 1 cost $2.5 million more per year than option 2, starting in year 10.

Under the calfhood vaccination options, increased federal costs were budgeted to cover the vaccine, tags and postage at 29¢ per head plus an additional 35¢ per head to cover additional federal costs associated with increased false-positive tests resulting from increased vaccination. Federal costs for vaccination increased, of course, directly as the level of herd vaccination increased among the three options of low level, medium level and high level vaccination. These federal costs associated with vaccination were added to the base program cost to get total federal program cost.

The same logic and per/head cost used in projecting federal cost with calfhood vaccination were used, also, in projecting federal costs

Table 30. Projected Federal Costs, by Program and Year (1976 Dollars)

		Program							
		Accelerated		Whole Herd Vaccination			Calfhood Vaccination		
Year	Base	1	2	Low	Medium	High	Low	Medium	High
	Thousand dollars								
0	36,834	36,834	36,834	36,834	36,834	36,834	36,834	36,834	36,834
1	36,834	42,889	42,889	45,100	45,100	45,100	39,517	41,894	43,626
2	36,834	53,979	53,979	50,571	58,837	58,837	39,517	41,894	43,626
3	36,834	74,149	74,149	39,733	53,470	61,736	39,517	41,894	43,626
4	36,834	93,789	93,789	37,992	40,890	54,628	39,517	41,894	43,626
5	36,834	97,453	97,453	37,992	39,149	42,048	39,517	41,894	43,626
6	36,834	93,200	93,200	37,992	39,149	40,307	39,517	41,894	43,626
7	36,834	91,400	91,400	37,992	39,149	40,307	39,517	41,894	43,626
8	36,834	77,800	77,800	37,992	39,149	40,307	39,517	41,894	43,626
9	36,834	66,300	66,300	37,992	39,149	40,307	39,517	41,894	43,626
10	36,834	56,600	54,100	37,992	39,149	40,307	39,517	41,894	43,626
11	36,834	45,200	42,700	37,992	39,149	40,307	39,517	41,894	43,626
12	36,834	37,000	34,500	37,992	39,149	40,307	39,517	41,894	43,626
13	36,834	32,400	29,900	37,992	39,149	40,307	39,517	41,894	43,626
14	36,834	30,600	28,100	37,992	39,149	40,307	39,517	41,894	43,626
15	36,834	29,000	26,500	37,992	39,149	40,307	39,517	41,894	43,626
16	36,834	28,000	25,500	37,992	39,149	40,307	39,517	41,894	43,626
17	36,834	27,000	24,500	37,992	39,149	40,307	39,517	41,894	43,626
18	36,834	26,500	24,000	37,992	39,149	40,307	39,517	41,894	43,626
19	36,834	26,000	23,500	37,992	39,149	40,307	39,517	41,894	43,626

for the whole-herd vaccination options, with one addition. A charge of $2.50 per head was added to cover the cost of required testing prior to adult vaccination. Although it is technologically possible to achieve a high level of herd vaccination in one year using full-herd vaccination, the model assumed that three years would be required to reach the low level (39.5%) of herd vaccination, four years to reach the medium level (74.5%) and five years to reach the high level (90%) of herd vaccination in all three regions.

Projected state expenditures

Under the cooperative state-federal brucellosis program, states are required to contribute at least 40 percent of the total state-federal expenditures under the program. In accounting for expenditures, states are permitted to include all identified costs of private operators. Not surprisingly both the accounting standards and the kinds of private operator costs included in state-reported expenditures vary substantially among states. Moreover, great variation exists among states, and within some states from year to year, in the types of programs supported by state funds and the levels of state funding for these various programs. Consequently, identifying and projecting state expenditures separately from producer costs based on reported data cannot be precise.

Our purpose is to account for all costs and still avoid double accounting. We are less concerned, at this moment, with whether the cost is borne by the state or private operator. This is not to say that the question of who pays particular costs might not be vital to the success of a particular practice such as vaccination, for example. But our present interest is in accounting rather than management and politics.

A summary of the projected state costs is presented in Table 31 by program alternative. State costs for both the base program and accelerated programs were projected at 66.7% of the federal costs each year for each of these programs, respectively. This ratio permits states to meet the 40 percent - 60 percent state-federal funding requirement. State costs for the various vaccination options for both calfhood vaccination and whole-herd vaccination, include 66.7% of the federal costs for the base program plus a $2 per head charge to cover veterinarian charges for vaccination. Above, although this cost will likely be paid by individual producers rather than state governments, it is usually reported as a part of state costs and was included as reported state expenditures in Table 31.

Table 31. Projected State Costs, By Program and Year (1976 Dollars)

	Program								
		Accelerated		Whole Herd Vaccination			Calfhood Vaccination		
Year	Base	1	2	Low	Medium	High	Low	Medium	High
	Thousand dollars								
0	24,568	24,568	24,568	24,568	24,568	24,568	24,568	24,568	24,568
1	24,568	28,607	28,607	30,849	30,849	30,849	32,952	40,381	45,794
2	24,568	36,004	36,004	33,915	42,254	42,254	32,952	40,381	45,794
3	24,568	49,457	49,457	29,294	40,700	46,980	32,952	40,381	45,794
4	24,568	62,557	62,557	28,185	32,912	44,316	32,952	40,381	45,794
5	24,568	65,001	65,001	28,185	31,803	36,529	32,952	40,381	45,794
6	24,568	62,164	62,164	28,185	31,803	35,420	32,952	40,381	45,794
7	24,568	60,964	60,963	28,185	31,803	35,420	32,952	40,381	45,794
8	24,568	51,893	51,893	28,185	31,803	35,420	32,952	40,381	45,794
9	24,568	44,222	44,222	28,185	31,803	35,420	32,952	40,381	45,794
10	24,568	37,752	36,085	28,185	31,803	35,420	32,952	40,381	45,794
11	24,568	30,148	28,481	28,185	31,803	35,420	32,952	40,381	45,794
12	24,568	24,679	23,012	28,185	31,803	35,420	32,952	40,381	45,794
13	24,568	21,611	19,943	28,185	31,803	35,420	32,952	40,381	45,794
14	24,568	20,410	18,743	28,185	31,803	35,420	32,952	40,381	45,794
15	24,568	19,343	17,676	28,185	31,803	35,420	32,952	40,381	45,794
16	24,568	18,676	17,009	28,185	31,803	35,420	32,952	40,381	45,794
17	24,568	18,009	16,342	28,185	31,803	35,420	32,952	40,381	45,794
18	24,568	17,676	16,008	28,185	31,803	35,420	32,952	40,381	45,794
19	24,568	17,342	15,675	28,185	31,803	35,420	32,952	40,381	45,794

Producer Costs

Producer costs associated with the the state federal brucellosis programs which are not included in the projections of state expenditures include added costs for labor, machinery, fuel, etc., for extra assembling and working cattle in connection with vaccinations and testings. Since data on the magnitude of these costs were not available, questions were included in the survey questionnaire mailed to a random sample of producers in selected states representing the eight regions. Based on this survey information, producer costs other than for vaccine and veterinary expenses are estimated separately for beef and dairy producers.

Beef producers

The costs per head to beef producers for the added labor required to handle the beef herd for vaccinations and testing varied considerably depending on herd size, as indicated in Table 32. However, when corrected for differences in herd size, there were few significant differences among regions. Producers reported that separate roundups had to be made for 40 percent of the vaccinations. Thus, the producer cost for vaccinating an animal in a 75-cow herd is estimated at $0.65 + (.40) ($0.92) = $1.02.

Table 32. Beef Producer Labor Costs per Head, by Size of Herd, 1976

Herd Size	For Vaccination	For Roundup (per roundup)
1- 19	$1.80	$1.07
20- 49	1.10	1.00
50- 99	.65	.92
100-199	.68	.92
200-499	.35	.89
500-999	.24	.63
1000 or more	.17	.44
Average	$0.35	$0.76

Where producers already had corrals, chutes and presses for working cattle, no additional costs were assigned for equipment. However, many producers reported having to rent portable chutes and a chute press and to hire the use of other equipment--including helicopters in some instances--to work their cattle for brucellosis testing. The average cost per head for all herds was $0.49 per head per test. However, as expected, the costs also varied inversely with size of herd as shown in Table 33.

Table 33. Total Costs for Equipment per Roundup, Beef Operations, by Herd Size and per Head, United States, 1976[1]

Herd Size (Herd)	Dollars per Herd	Dollars per Head
1- 19	10.11	.65
20- 49	13.62	.45
50- 99	28.47	.43
100-199	52.44	.40
200-499	112.78	.40
500-999	126.96	.31
1000 or more	552.23	.26
Average	18.33	.49

The average number of tests required to clear up an infected herd varies by herd size and by year of quarantine as outlined for both beef and dairy herds in Table 34. The data in Table 34 were estimated from preliminary data supplied by regional epidemiologists in the southeast regions and from data collected in our own survey of states in each region. Labor and equipment costs for testing were estimated by multiplying the relevant costs per head listed in Tables 32 and 33 for the appropriate herd size by the relevant number of tests per herd for that herd size as shown in Table 34. To illustrate, the per-head costs for labor and equipment for a 75-cow operation which cleaned up in the first year of quarantine would be estimated at:

$$4.5\ (\$0.92 + 0.43) = \$6.08$$

Where 4.5 is the average number of herd tests required to clean up for herds in the 50-99 herd-size that cleaned up the first year (from Table 34); $0.92 is the average per head labor cost per test for herds of this size (from Table 32) and $0.43 is average per-head equipment rental cost per test for herds of this size (from Table 33).

Dairy Producers

We assume that producer labor costs for vaccinations estimated for beef herds is also reasonable for dairymen of corresponding herd size. Since a separate "round-up" is not needed for vaccinating dairy calves, this cost is ignored. Moreover, we assume that dairymen will not need to rent special equipment for working cattle either for brucellosis testing or for vaccination. The average labor cost per head for brucellosis testing reported by dairyment was $0.34, but varied by herd size as shown in Table 35.

Table 34. Number of Tests Required to Clean-up Infected Beef and Dairy Herds, by Year of Quarantine and Herd Size, Herds with Less than 20 Percent Vaccination Level[a]

Type of herd and herd size (head)	Year of Quarantine		
	1	2	3
	Number of tests		
Beef:			
1 - 19	3.5	1.5	0
20 - 49	4.0	2.0	1.5
50 - 99	4.5	3.0	2.0
100 - 199	5.0	3.5	2.5
200 - 499	5.5	4.0	3.0
500 - 999	6.0	4.5	3.5
1000 or more	6.0	5.0	4.0
Dairy:			
1 - 19	4.0	2.0	0
20 - 49	4.5	2.5	2.0
50 - 99	5.0	3.5	2.5
100 - 199	5.5	4.0	3.0
200 - 499	6.0	4.5	3.5
500 - 999	6.5	5.0	4.0
1000 or more	6.5	5.5	4.5

[a] The total number of tests required to clean-up infected beef herds can be estimated as follows using herd size 1-19 as an example:

(1) The number of tests for herds cleaned-up during the first year of quarantine for herd size 1-19 = (clean-up rate during the first year of quarantine)(number of infected herds in first years of quarantine) (3.5), and

(2) number of tests for herds cleaned-up during the second year of quarantine for herd size 1-19 = (net clean-up rate during second year of quarantine)(number of infected herds in second year of quarantine)(5). Herds cleaned up during the second year of quarantime undergo a total of 5 tests for herd size 1-19. This represents 3.5 tests during the first year of quarantine and 1.5 tests during the second year of quarantine. The same methodology was used for computing the total number of tests for other herd sizes by year of quarantine. Adjustments or decreases in the number of tests required to clean-up infection as a result of vaccinal effectiveness was .95 for 20 to 59 percent herd vaccination levels, .80 for 60 to 89 percent vaccination levels, and .55 for 90 percent or higher vaccination levels.

Table 35. Producer Labor Costs per Head for Testing Dairy Cattle for Brucellosis, by Herd Size, 1976

Size of Herd	Average cost per head per test
1- 19	$0.54
20- 49	.50
50- 99	.46
100-199	.44
200-499	.37
500 or more	.22
Average	$0.34

Total producer costs

A summary of projected producer costs is presented in Table 36 for the several program alternatives. Producer costs under the base program varied with the number of cattle tested. The number of cattle tested is influenced by herd size, the number of herds under quarantine and the number of tests required to clean-up infected herds. Base program producer costs included costs associated with labor, equipment, fuel, etc. for extra assembling (roundups) and testing of cattle for brucellosis and are shown in Tables 32 and 33.

Under the accelerated program series, producer costs varied according to the number of cattle included in the area testing programs and the number of cattle and tests associated with quarantined herds. Producer costs were similar for the accelerated-1 and accelerated-2 options except that the number of infected cattle increased in the latter part of the accelerated-2 (starting in year 10) relative to the accelerated-1 program. Producer costs associated with roundups and testing of quarantined herds consequently were higher for the accelerated-2 program.

The two major producer cost items affected by calfhood vaccination responded inversely as the herd level of vaccination increased. On the one hand, costs associated with vaccination increased directly as the number of animals vaccinated increased. On the other hand, the number of infected cows tended to decrease as herd levels of vaccination increased, which, in turn, decreased producer costs associated with roundups and testing of quarantined cattle. However, decreased costs for testing were not proportional to the increases in vaccination levels because the number of "false positives" were projected to increase as the level of vaccination increased. On balance, total producer costs increased as vaccination levels increased.

Producer costs for the whole-herd vaccination programs were influenced by labor and equipment costs associated with roundups and testing for adult vaccination, by roundups and chute-work to process

Table 36. Projected Producer Costs, By Program and Year

Year	Base	Accelerated 1	Accelerated 2	Whole Herd Vaccination Low	Whole Herd Vaccination Medium	Whole Herd Vaccination High	Calfhood Vaccination Low	Calfhood Vaccination Medium	Calfhood Vaccination High
	Thousand dollars								
0	13,674	13,674	13,674	13,674	13,674	13,674	13,674	13,674	13,674
1	17,416	19,155	19,155	21,204	21,204	21,204	28,780	38,849	46,185
2	18,847	20,327	20,327	23,079	27,221	27,221	30,211	40,279	47,615
3	19,917	20,996	20,996	19,669	24,375	27,995	27,413	37,481	44,817
4	19,861	23,490	23,490	17,912	20,445	24,494	23,525	33,594	40,930
5	21,955	22,706	22,706	19,221	20,646	22,028	21,303	29,282	36,618
6	22,066	20,150	20,150	18,165	19,990	21,231	21,435	29,542	35,050
7	23,578	16,238	16,238	18,583	20,071	21,368	21,939	29,948	31,989
8	27,212	15,036	15,036	20,973	21,102	22,422	23,907	31,585	33,250
9	27,752	12,965	12,965	20,378	21,031	22,161	24,063	31,628	32,911
10	25,131	10,371	10,201	18,254	19,442	20,734	21,370	29,539	32,233
11	24,504	8,933	8,343	17,006	18,845	20,360	20,611	28,695	31,987
12	24,733	8,062	8,214	16,658	18,599	20,435	20,613	28,970	32,088
13	25,730	7,393	8,800	16,385	18,545	20,530	21,349	29,313	32,114
14	23,698	6,102	8,343	15,179	17,824	19,647	19,660	28,026	31,702
15	23,511	5,372	8,470	14,622	17,545	19,622	19,583	27,798	31,694
16	23,874	4,864	8,752	14,152	17,352	19,543	19,412	27,721	31,638
17	23,233	4,230	8,637	13,548	16,975	19,191	18,974	27,411	31,487
18	23,572	3,762	8,861	13,490	17,411	19,519	19,542	27,929	31,767
19	21,331	3,026	8,095	12,166	15,821	18,648	18,061	26,741	31,105

suspected and/or detected infected cattle, and by roundups and chute-work for calfhood vaccination. Although producer costs associated with roundups and chute-work for quarantine testing tended to decrease as vaccination levels increased, this was offset by increasing producer costs for roundups for testing prior to adult vaccination, and by roundups and chute-work for calfhood vaccination. The net results were that total producer costs increased as whole-herd vaccination levels increased.

A Summary and Comparison of Costs By Program Alternative

A summary of state, federal and producer costs projected by years covering a 20-year period for each program alternative is presented in Table 37. These cost data are expressed in terms of 1976 dollars. They will be used in Chapter VI in computing benefit/cost ratios and other economic criteria.

Table 37. Projected Total Costs, By Program and Year

	Program								
		Accelerated		Whole Herd Vaccination			Calfhood Vaccination		
Year	Base	1	2	Low	Medium	High	Low	Medium	High
	Thousand dollars								
0	75,077	75,077	75,077	75,077	75,077	75,077	75,077	75,077	75,077
1	78,819	90,651	90,651	97,153	97,153	97,153	101,249	121,124	135,604
2	80,249	110,309	110,309	107,565	128,311	128,311	102,679	122,554	137,035
3	81,319	144,603	144,603	88,696	118,545	136,709	99,882	119,757	134,237
4	81,264	179,836	179,836	84,089	94,248	123,440	95,995	115,870	130,350
5	83,358	185,160	185,160	85,398	91,599	100,604	93,772	111,557	126,037
6	83,468	175,514	175,514	84,342	90,942	96,957	93,904	111,817	124,470
7	84,981	168,601	168,601	84,759	91,024	97,095	94,408	112,224	121,409
8	88,615	144,729	144,729	87,150	92,055	98,149	96,376	113,861	122,670
9	89,155	123,487	123,487	86,555	91,984	97,888	96,532	113,904	122,331
10	86,534	104,723	100,386	84,431	90,395	96,461	93,840	111,814	121,652
11	85,906	84,281	79,524	83,183	89,798	96,087	93,080	110,971	121,407
12	86,136	69,741	65,726	82,834	89,552	96,161	93,082	111,245	121,508
13	87,132	61,404	58,643	82,562	89,497	96,257	93,819	111,589	121,534
14	85,100	57,112	55,186	81,356	88,776	95,374	92,129	110,302	121,122
15	84,913	53,715	52,645	80,798	88,498	95,349	92,052	110,073	121,113
16	85,276	51,540	51,260	80,329	88,304	95,270	91,882	109,996	121,058
17	84,635	49,239	49,478	79,725	87,927	94,918	91,444	109,686	120,906
18	85,975	47,937	48,869	79,667	88,363	95,246	92,011	110,204	121,187
19	82,734	46,368	47,269	78,343	86,773	94,374	90,530	109,016	120,525

CHAPTER VI: BENEFIT COST RATIOS

Projections of the economic benefits associated with selected alternative brucellosis control programs were presented in Chapter IV. These costs were expressed in terms of 1976 dollars. Projections of costs (including state, federal and producer costs) associated with each program were presented in Chapter V. These figures were also expressed in terms of 1976 dollars. We are now in position to make an economic evaluation of the program alternatives under consideration.

Three alternative economic criteria are used in comparing alternative policies or programs:

(1) Benefit/cost Ratios, which are calculated by dividing the present value of the projected change in benefits over the relevant planning horizon (20 years in our model) by the present value of the projected change in costs;

(2) The Net Present Value, which is calculated by subtracting the present value of the projected change in costs from the present value of the projected change in benefits; and

(3) The Internal Rate of Return (I.R.R.), which is defined as the rate of discount, which will make the present values of the projected stream of benefits just equal to the present value of the projected stream of costs.

The present value of I.R.R. criteria will always give the same economic ranking of alternatives. However, it is quite possible to obtain a different economic rating if benefit/cost ratios are used. This is particularly true when changes in costs from the base program may be small or even negative, as is the case in this analysis, as we shall see. As a consequence, the benefit/cost ratio is an inferior criterion for making economic evaluations of alternative policies. However, because the Commission has been charged with making a benefit/cost analysis, we have used two measures: the benefit/cost ratio and the present value of net benefits.

The following procedure was used in making the economic evaluation.

First, both annual benefits and annual costs were converted from "1976" dollars to "current year" dollars using an assumed 5 percent annual rate of inflation.

Second, to place the benefits and costs on a common time pattern, the projected annual data were converted to present value using a 9.0 percent discount rate. The accumulated present value of projected changes in benefits for each program alternative, relative to the base program, is listed by program alternative in column 1 of Table 38, while the present values of accumulated costs are shown in column 2.

Third, the program cost for the base program was entered in column 3 of Table 38. This figure was then subtracted from column 2 to get marginal program cost for each alternative, which is listed in column 4.

Fourth, the marginal benefit/cost ratio was calculated by dividing the change in benefits by changes in costs. (Column 1 ÷ column 4). The marginal benefit/cost ratio is presented in column 5. The net present value of each alternative (column 1 minus column 4) is shown in column 6 under the heading "net benefits."

Table 39 lists the order ranking of the several program alternatives according to four criteria all taken from Table 38: (1) the present value of the change in benefits (column 1), (2) the present value of program costs (column 2), (3) the benefit/cost ratio (column 3) and (4) the net present value (column 4). A comparison of these separate rankings provides an insight into the contributions which each of these program alternatives might make toward a total program of control leading toward local eradication, although only the latter two criteria are considered, by themselves, to provide a ranking useful for policy considerations. Keep in mind throughout this discussion that each comparison represents the movement from the base program to the particular program alternatives being compared.

From these calculations, and within the limits of ability of the model to simulate outcomes, several generalizations can be made:

Vaccination (both calfhood and "whole-herd") superimposed on the base program in the selected regions, was found to be effective in reducing physical losses. Moreoever, the level of herd vaccination is strongly and positively related to economic benefits. In this analysis, calfhood vaccination generated more benefits than did whole-herd vaccination. This is true however because, in the model, whole herd vaccination was applied, in addition to the base program, only in the three high prevalence regions, while calfhood vaccination was applied in all regions except 1, 2 and 8. It must be understood that in region 8, and in some states in region 1, present vaccination levels are already at or higher than the medium level. Furthermore in regions 1, 2 and 8 prevalence is already low, so it would be inappropriate to generalize the extent to which benefits would be increased still further by extending these vaccination levels to all regions.

When ranked according to program costs, with the lowest cost alternative ranked first, the order is somewhat reversed from the previous ranking, with the "no program" alternative well out in front, having zero costs. High-level calfhood vaccination, on the other hand, ranked lowest. An important deterrent to high-level vaccination, of course, is the high level of program costs which continue indefinitely into the future. The calfhood vaccination options ranked below the corresponding level of whole-herd vaccination because of the greater area covered by calfhood vaccination.

In terms of the benefit/cost ratios, the whole herd vaccination al-

Table 38. Total Benefit/Cost Ratios, Various Program Alternatives Relative to the Base Program[a]

Program	Change In Benefits[b]	Program Costs	Base Program Costs	Marginal Program Costs[c]	Marginal Benefit/Cost Ratio[d]	Net Benefits[e]
	---Million dollars---				Ratio	Million dollars
Accelerated - 1	615.4	1,598.0	1,356.6	241.4	2.55	374.0
Accelerated - 2	535.8	1,597.6	1,356.6	240.0	2.23	294.9
Calfhood Vaccination-Low	651.9	1,515.4	1,356.6	158.8	4.11	493.1
Calfhood Vaccination-Medium	980.2	1,733.1	1,356.6	376.5	2.60	603.7
Calfhood Vaccination-High	1,064.2	1,896.2	1,356.6	539.4	1.97	524.7
Whole Herd Vaccination-Low	636.0	1,274.7	1,356.6	-81.9	7.76	718.0
Whole Herd Vaccination-Medium	802.2	1,390.0	1,356.6	33.4	24.02	768.9
Whole Herd Vaccination-High	894.3	1,504.6	1,356.6	148.0	6.04	746.3
No Program	-16,854.5	-0-	1,356.6	-1,356.6	-12.42	-15,497.8

a/ Computed for 19 years or from 1977 to 1995 and represent discounted present values.

b/ Total change in benefits of the program alternative over the basic program.

c/ Total program costs minus the base program costs.

d/ Change in benefits (column 1) divided by marginal program costs (column 4).

e/ Change in benefits (column 1) minus marginal program costs (column 4).

Table 39. Ranking of Program Alternatives by Selected Criteria

Program Alternative	Change in Benefits (Column 1 of Table 38)	Program Costs (Column 2 of Table 38)	Benefit/ Cost Ratio (Column 5 of Table 38)	Net Benefits (Column 6 of Table 38)
	(Rank)			
Accelerated Option 1	7	7	6	7
Accelerated Option 2	8	6	7	8
Calfhood Vaccination Low-Level	5	5	4	6
Calfhood Vaccination Medium Level	2	8	5	4
Calfhood Vaccination High Level	1	9	8	5
Whole-herd Vaccination Low Level	6	2	2	3
Whole-herd Vaccination Medium Level	4	3	1	1
Whole-herd Vaccination High Level	3	4	3	2
No program	9	1	9	9

ternatives ranked highest, with the medium-level option first and the low-level and high-level following somewhat behind but close together. The low-level and medium-level calfhood vaccination options came in fourth and fifth, respectively, followed in order by accelerated program 1 and accelerated program 2. The high-level calfhood vaccination, which ranked first in terms of total benefits, ranked 8th in terms of the benefit/cost ratio.

In terms of net benefits, the order again changed just a little. The only significant change, however, was that the high-level calfhood vaccination option moved up from 8th to 5th, while low-level calfhood vaccination dropped from 4th to 6th. These changes point out a weakness of the benefit/cost ratio. When marginal costs are low, a very modest adjustment in either costs or benefits can change the benefit/cost ratio substantially.

Again, it should be pointed out that it is inappropriate to generalize the value of the added program variable "whole herd vaccination" which was modeled in three high prevalence regions to the entire country. We specifically did not model this alternative in all regions, first, because it would be of questionable epidemiologic value broadly applied in the low prevalence regions, and secondly, because it would be extremely costly.

The very favorable ranking of the whole-herd vaccination options, combining, as they did, herd testing, holds considerable promise of an approach that could materially reduce the level of herd infection in the high prevalence regions, once this practice has been approved and adopted. However, the medium-level of herd vaccination (60-89 percent) for any region is higher than can reasonably be expected based on historical performance records and current producer attitudes.

The results of this computer simulation strongly support the proposition made in Section 6, that losses can be greatly reduced by a combined strategy of judicious selection of herds in the high prevalence areas for whole-herd vaccination, combined with elimination of reactors on the basis of improved application of diagnostic criteria. It seems likely that both program and producer costs can be minimized, while herds and areas progress toward local eradication, if selection of both the infected and noninfected herds at high risk is focused on those where epidemiologic evaluation indicates greatest potential of spread of infection because of geographic proximity or trading patterns.

Although the difference in net benefits and benefit/cost ratios between accelerated programs 1 and 2 appear to be relatively small, they merit comment. Recall that the basic difference between these two options was that in option 1 the high level of program performance achieved during the period when area testing and first point of concentration (FPC) testing were taking place was assumed to be maintained indefinitely into the future. In option 2, on the other hand, program performance was assumed to drop back within two years after FPC ceased, to the level which prevailed in the region prior to when area

testing began. The higher performance level in the first option is manifest in a flow of benefits with a present value which is approximately $80 million higher than for option 2. At the same time, the present value of the two cost streams differ very little. However, more of the costs under option 1 represents educational and training programs designed to maintain a high level of program participation and performance. In option 2, more of the costs were attributable to the higher levels of infection.

A comparison of both the relative magnitude and time patterns of the accumulated present value of the "streams of net benefits" associated with different programs can be seen more readily in Figure 4, which compares accelerated program options 1 and 2 and the medium level of both the calfhood and whole-herd vaccination programs. The early economic advantages offered by testing and whole-herd vaccination in selected high prevalence areas is indicated. On the other hand, the early, short-run cost of the accelerated program is such that a planning horizon of nearly 12 years is required in order for that program to "break-even," after which rapid economic rewards are shown -- especially for option 1. However, in the absence of any additional programs such as increased vaccination, other than one-time area testing in high prevalence areas infection is projected to stabilize after about 17 years. The fluctuations in accumulated benefits manifest in these programs result from the interactions of the epidemiologic assumptions, the cattle cycle and the exogeneous economic variables built into the economic model. The fact that accumulated net benefits declined during the last year or two under all modeled options warrants further testing to see if this phenomenon merely represents a temporary cyclical downturn, or signals a possible turning point where projected costs finally overtake projected benefits. Within a planning horizon range of 12 to 18 years, however, the answer, as projected in this study, clearly shows that each program alternative promises prositive net benefits when compared to the base program.

It might be insightful to look at the consumer and producer sectors using consumer surpluses and producer surpluses separately. This information is shown in Table 40. These data clearly show which sectors lose and which gain from brucellosis control programs. In general, those programs which reduce infection and thereby increase supplies of beef and milk, lead to lower commodity prices which benefit consumers. Consider, for example, which groups gain or lose the most by shifting from the base program to a high level of whole-herd vaccination. This analysis indicates that consumers would be made better off by more than $2.0 billion over the 20-year program, representing a return of more than $14 on every dollar invested. However, producers would be made <u>worse off</u> by more than $1.2 billion over this same period, representing a loss of more than $8 to producers for every dollar invested in the program.

On the other hand, the benefit/cost ratio to producers is very high under the "no program" option owing to the high beef and milk prices that result from the heavy physical losses with no program. Clearly, those producers who can escape the ravages of this disease stand to gain the

COMPARISON OF NET BENEFITS FOR SELECTED PROGRAMS BY YEARS

FIGURE 4

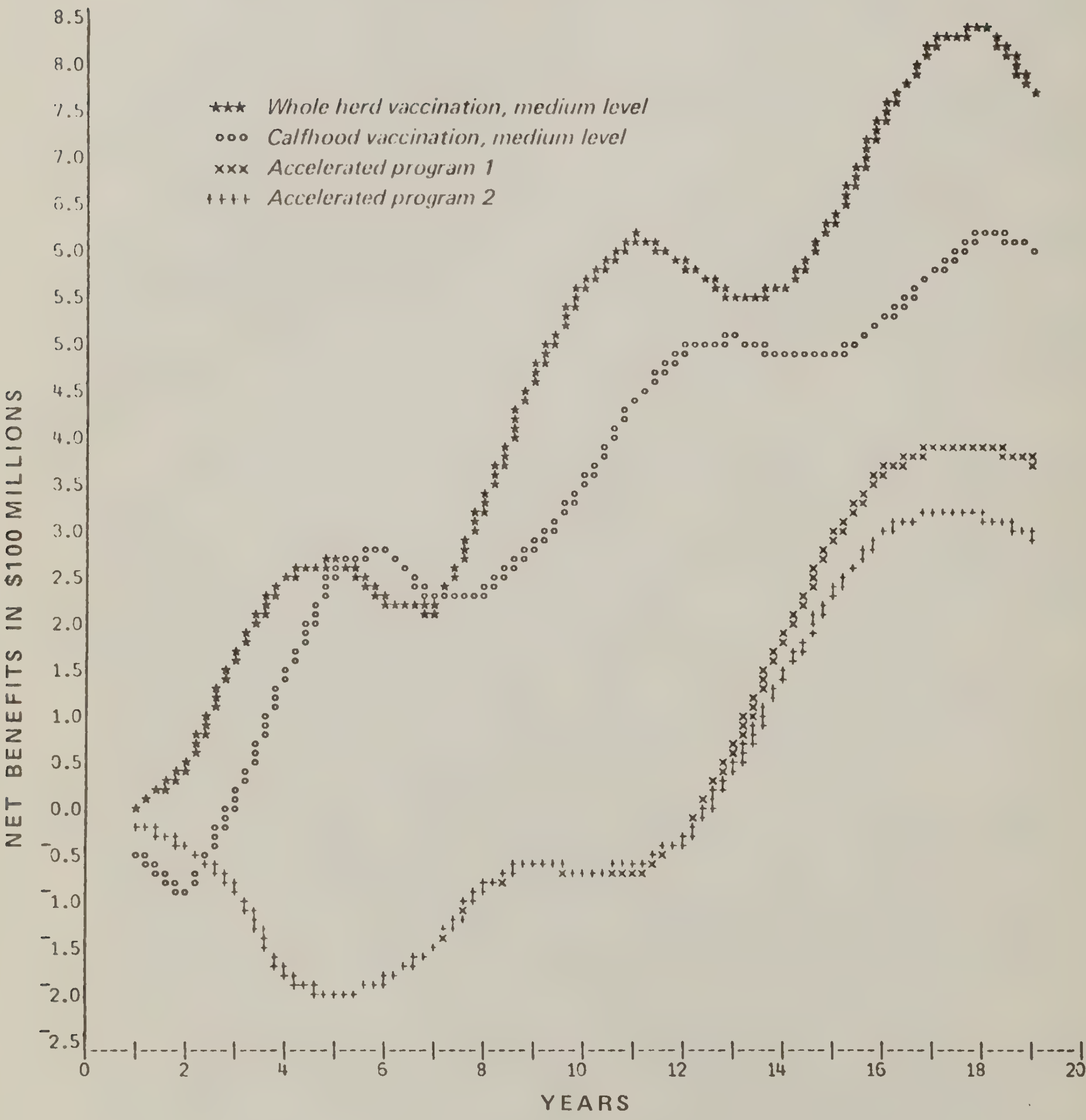

Table 40. Consumer and Producer Benefit/Cost Ratios, Various Program Alternatives Relative to the Base Program[a]

Program	Consumer Sector					Producer Sector[b]	
	Change In Benefits[c]	Program Costs	Base Program Costs	Marginal Program Costs[d]	Marginal Benefit/Cost Ratios[e]	Change In Benefits[c]	Marginal Benefit/Cost Ratios
	-----------Million dollars-----------				Ratio	Mil. dollars	Ratio
Accelerated - 1	1,418.7	1,598.0	1,356.6	241.4	5.88	-803.3	-3.33
Accelerated - 2	1,249.0	1,597.6	1,356.6	240.0	5.18	-713.1	-2.96
Calfhood Vaccination-Low	1,476.6	1,515,4	1,356.6	158.8	9.30	-824.7	-5.19
Calfhood Vaccination-Medium	2,159.7	1,733.1	1,356.6	376.5	5.74	-1,179.5	-3.13
Calfhood Vaccination-High	2,353.1	1,896.2	1,356.6	539.4	4.36	-1,288.9	-2.39
Whole Herd Vaccination-Low	1,583.4	1,274.7	1,356.6	-81.9	19.32	-947.4	-11.56
Whole Herd Vaccination-Medium	1,974.1	1,390.0	1,356.6	33.4	59.21	-1,171.9	-35.15
Whole Herd Vaccination-High	2,170.9	1,504.6	1,356.6	148.0	14.67	-1,276.6	-8.63
No Program	-35,029.4	-0-	1,356.6	-1,356.6	-25.82	18,175.0	13.40

a/ Computed for 19 years or from 1977 to 1995 and represent discounted present values.

b/ The program costs, base program costs and marginal program costs indicated for the consumer sector also apply for the producer sector.

c/ Total change in benefits of the program alternative over the base program.

d/ Total program costs minus the base program costs.

e/ Change in benefits divided by marginal program costs.

most in the absence of any government programs. But under this option in the model, national infection rates would rise in the 19th year to approximately 45% of dairy herds and 70% of beef herds, so that individual producers would have to make substantial efforts to maintain their herds free of infection. They would also have to deal with the uncertainty imposed by the threat of infection. Those producers who could not maintain herds free from infection would be hard pressed to compete. At the same time, in the absence of any government program, the losses in product would be translated into substantial costs to the consumer. The high negative benefit/cost ratio suggests that for every dollar saved by the elimination of even the base program (which merely maintained infection at the prevailing level) would result in a loss to consumers of about $26.00.

Remember that this analysis did not include the economic benefits associated with improved human health attributable to lower levels of bovine brucellosis infection. Nor did it give consideration to reduced pain and suffering associated therewith. Furthermore, for want of data on which to base estimates, economic benefits accruing to producers from greater freedom of movement of livestock associated with diminished levels of infection were also ignored. An important benefit to individual producers from control programs leading to local eradication of brucellosis would be the reduction and final elimination of these important risks.

The reader should again be cautioned that this analysis was based on estimates of both herd infection levels and physical losses requiring judgements on matters where data and knowledge were limited. Although the Commission went to great length to gather information from all known sources, and tried to be as realistic as possible in making estimates, the final benefit/cost ratios and net benefits could, in the real world, vary somewhat from those presented. However, the analysis indicates that errors within a range of plus or minus 50 percent would not alter the conclusions that positive economic returns can be expected from dollars invested to move from the base program by the addition of any one of the activities comprising the brucellosis program alternatives considered in this study. Moreover, the fact that the "no program" alternative ranked so dramatically low in terms of both the benefit/cost ratio and net benefits, leaves no question about the positive economic benefits of the cooperative state-federal program - even as it existed in 1975-76, when compared to having no program.

ANNEX 1

THE SIMULATION MODEL AND BASIC DATA INPUTS

The Beef and Dairy Simulation Model

The basic model (NBTC model) used to measure the impact of various brucellosis policy alternatives upon the spread, control and/or eradication of brucellosis upon the beef and dairy sectors of the cattle industry in the United States was a computer simulation model. A flow diagram of this model is shown in Figure 2.

The NBTC model determined simultaneously the effect of various policy alternatives upon the beef and dairy sector and was structured such that the disease was transmitted among and between beef and dairy herds in approximately the same manner as presently occurs within the cattle industry. In addition, the model was designed such that infected and detected herds could be placed in a "quarantined" status while undetected infected herds remained on a non-quarantined status. The subdivision of infected herds into quarantined and non-quarantined herds has a major impact upon physical losses, spread of the disease, and clean-up rates.

Some of the major mathematical components of the NBTC model which may require further elaboration are (1) the Probability of Detection, (2) the Double Binomial, and (3) the Neighborhood Spread Formula. The functions and mathematical components of these items are described as follows:

The Probability of Detection

To calculate the number of newly quarantined herds in the beef population, the probability of undetected infected herds being detected has to be estimated. These detection probabilities were calculated by an approximation of a hypergeometric distribution.[1/] Detection probabilities varied by region, herdsize, year of infection, cull rate cycle, MCI rate and level of vaccination:

$$DP = 1 - \left(\frac{A - I - S/2 + .5}{A - S/2 + .5}\right)^{S}$$

1/ For a detailed description of a hypergeometric distribution consult Regulatory Statistics, 5th edition, APHIS, Veterinary Services, Animal Science Dept. of Agriculture; June, 1975, Part III, OR Cochran, W. G. (1963). Sampling Techniques, 2nd edition, John Wiley & Sons, Inc., New York, pp. 55-57.

where

DP = detection probability
A = number of cows culled
I = number of infected cows culled
S = number of cows culled under surveillance system

For example, in the base program, the detection probability of an undetected infected herd in the second year of infection located in region 1 for herdsize 20 - 49 is calculated below. Detection probabilities were used in combination with the quality control factor for that region in determining the number of newly quarantined herds each year.

Given:

Region 1
Cull Rate (CR) = .20
Infection Rate Year 2 (IR) = .30
Average Cows in 20 - 49 herdsize group (AC) = 29.2070
MCI = .70

where

A = AC x CR
I = AC x CR x IR
S = AC x CR x MCI

Therefore

A = 5.84140
I = 1.75242
S = 4.08898

$$DP = 1 - \left(\frac{5.84140 - 1.75242 - 4.08898/2 + .5}{5.84140 - 4.08898/2 + .5}\right)^{4.08898}$$

DP = 1 - .11736
DP = .88264

The Double Binomial

A double binomial was used to simulate the spread of the disease through the purchase of infected replacements.[2/] Due to the nature of

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[2/] For elaboration on the double binomial, see Beal, Victor J., The Use of the Double Binomial In Animal Disease Work, APHIS Working Paper, U.S. Department of Agriculture, October, 1971.

the cattle industry, parameters, p, s, q, m and n, defined below were necessary for calculating the double binomial which is defined as:

$$1 - [(q + ps^{m})^{n}]$$

where

$$p = \frac{\text{Number of cows in infected herds in the region}}{\text{Total number of cows in the region}}$$

$$q = \frac{\text{Number of cows in brucellosis free herds in the region}}{\text{Total number of cows in the region}}$$

$$s = 1 - \left(\frac{\text{Total number of infected cows in region}}{\text{Total number of cows in infected herds in region}} \right)$$

n = Number of sources from which replacements were purchased

$$m = \frac{\text{Number of replacements purchased annually}}{\text{Number of sources}}$$

Parameters p, s, and q were dependent on the number of undetected infected cows and herds in the region. Therefore, p, s, and q changed from year to year as the undetected infected population expanded or contracted.

Parameters m and n were calculated in the initial year of the model by region and herdsize group. M and n were held constant for the rest of the years of the simulation.

The double binomial was modified in order to allow for inter-regional movement of breeding stock. Each region had a certain probability of purchasing from within their own region and each of the seven other regions. Regional purchase probabilities are discussed in a later section of this Annex. These probabilities always summed to 1 for any given purchasing region and were held constant throughout the simulation.

$$PP_{hij} = \sum_{LL}^{LL\,=\,1,8} \left[\left(\text{Regional Purchase Probability} \right)_{hiLL} \times \left(1 - \left(\left(q + PS^{m} \right)^{n} \right)_{hij} \right] \right.$$

where

PP = The probability of a region purchasing one or more infected replacements

h = 1, 2 species (1 = beef, 2 = dairy)

i = 1, 8 purchasing regions
LL = 1, 8 regions from which replacements are purchased
j = 1, 7 herdsize groups

To arrive at the number of newly infected herds, the probability of a herd purchasing one or more infected replacements by herdsize and region was multiplied by the number of clean herds in that herdsize group and region.

$$NI_{hij} = PP_{hij} \times NCLEAN_{hij}$$

where

NI = number of newly infected herds
PP = probability of purhcasing one or more infected replacements
NCLEAN = number of clean herds in the region
h = 1, 2 species
i = 1, 8 regions
j = 1, 7 herdsizes

Neighborhood Spread

The second method in which a clean herd could become infected was through contact with a neighboring infected herd. The first step in determining the number of newly infected herds through neighborhood spread was to calculate the weighted total infected herds. A quarantined herd was assumed to have one-half the spread of a first year undetected infected herd (equation 1).

The newly adjusted undetected infected herds were then weighted by their year of infection and totaled over herdsize, year of infection and species for the region. (equation 2).

$$1)\quad INF_{hijl} = \sum_{L}^{L\,=\,1,3} \sum_{k}^{k\,=\,1,3} QUAR_{hijkL}$$

$$2)\quad T_i = \sum_{h}^{h\,=\,1,2} \sum_{j}^{j\,=\,1,7} \sum_{k}^{k\,=\,1,3} (INF_{hijk} \times WINF_{hik})$$

where

INF = undetected infected herds
QUAR = quarantined infected herds
T = total weighted infected herds
WINF = weighted infection rate where $WINF_{hik} = \dfrac{INFR_{hik}}{INFR_{hi2}}$

INFR = within herd infection rate
i = 1, 8 regions
j = 1, 7 herdsizes
k = 1, 3 years of infection
L = 1, 3 years of quarantine
h = 1, 2 species

Newly infected herds due to neighborhood spread were then calculated by multiplying the weighted total infected herds (T) by the probability of a herd becoming infected (NS) which varied by region and species. These newly infected herds were distributed to the herdsize groups on the basis of their weighted population proportions (WPP).

$$INF_{hijl} = T_i \times NS_{hi} \times WPP_{hij}$$

where

NS = neighborhood spread factor
INF = undetected infected herds
T = weighted total infected herds
WPP = $\dfrac{\text{number of herds by herdsize group and species in region}}{\text{Total number of herds in region}}$

h = 1, 2 species
i = 1, 8 regions
j = 1, 7 herdsizes
k = 1, 3 years of infection

Basic Data Inputs

In order to provide as much detail and realism as available data permitted, the United States was sub-divided into eight regions in the NBTC simulation model as shown in Figure 1. The basic data inputs in the model for the beef and dairy sector, for each region, included (1) the number of herds by herdsize, (2) the average number of cows per herd by herdsize, (3) the proportion of replacement purchased, (4) the source ration or the number of herds from which replacements were purchased, (5) the regional purchase probability, (6) the numbers of infected herds, (7) infection rates, (8) clean-up rates, (9) neighborhood spread, (10) cull rates, (11) MCI and BRT rates, (12) a regional quality control factor, (13) residual infection rates, and (14) vaccinal protection effectiveness. The detailed data for each of these input items are as follows:

The Number of Herds by Herdsize

The NBTC model used numbers of herds by herdsize as the basic input units because (1) beef and dairy herds are the units most often quarantined, when detected, and (2) data on a herdsize basis were available. The proportion of herds, by herdsize, for the United States beef and dairy cow sectors were derived from the 1974 Census of Agriculture, Volume 1, State and County data and aggregated on a regional basis for this study. The number of operations with cattle and milk cows for 1975 and 1976, by state, were obtained from CATTLE, LvGn 1 (1-78) as reported by the Statistical Reporting Service, U. S. Department of Agriculture, January 30, 1978. The number of operations with cattle were adjusted by the proportion of beef operations with cows as reported by the 1974 Census of Agriculture to reflect only operations with beef cows. The estimated number of beef and dairy herds, by herdsize and region, using the above data sources are shown in Tables A1.1 and A1.2, respectively. Further, regional epidemologists and others associated with the dairy industries reported that many of the reported dairy herds in herdsize 1-19 in all regions and herdsize 20-49 in region 4 were used for beef production rather than dairy production. The number of beef and dairy herds shown in Tables A1.1 and A1.2, therefore, reflect the primary productive use of cows regardless of beef or dairy breeding. Consequently, the proportion of dairy herds in herdsize 1-19 transferred from the dairy sector to the beef sector by region, were: region 1, 50 percent; region 2, 50 percent; region 3, 90 percent; region 4, 90 percent; region 5, 75 percent; region 6, 33 percent; region 7, 67 percent; and region 8, 90 percent. In addition, 75 percent of the dairy herds in herdsize 20-49 in region 4 were transferred to the beef sector to reflect primary productive use.

The average number of beef and dairy cows per herd, by region and herdsize, are shown in Tables A1.3 and A1.4, respectively. These data also reflect the primary productive use of cows regardless of breed. The final beef cow inventory numbers by region for 1975-76 were as follows:

Region	Beef Cows	Dairy Cows
	------------Head	---------------
1	4,191,203	5,682,968
2	1,889,048	429,065
3	6,746,417	760,688
4	1,351,319	312,273
5	11,425,348	665,726
6	11,555,534	1,194,172
7	6,915,998	672,830
8	1,242,825	793,586

Table A1.1. Estimated Number of Beef Cow Herds, by Region and Herdsize, United States, 1975-76

Region	Herdsize (Head)							
	1-19	20-49	50-99	100-199	200-499	500-999	1000 or more	Total
	Herds							
1	178,851	49,984	11,596	2,870	562	49	15	243,927
2	68,587	21,408	5,578	1,654	502	46	13	97,788
3	162,152	70,252	22,549	7,432	2,370	268	51	265,074
4	8,540	4,184	1,986	1,070	725	227	200	16,932
5	121,965	82,267	34,838	14,402	6,494	1,254	476	261,696
6	104,888	94,489	46,484	18,016	5,587	589	170	270,223
7	48,355	18,479	12,854	9,423	6,364	1,493	575	97,543
8	10,758	3,218	1,680	1,307	916	313	159	18,351
Total	704,096	344,281	137,565	56,174	23,520	4,239	1,659	1,271,534

Table A1.2. Estimated Number of Dairy Cow Herds, by Region and Herdsize, United States, 1975-76

Region	Herdsize (Head)						
	1-19	20-49	50-99	100-199	200-499	500 or more	Total
	Herds						
1	33,590	88,656	30,607	4,783	591	27	158,254
2	13,428	2,614	2,108	915	197	11	19,273
3	4,328	6,948	3,758	1,443	363	29	16,869
4	250	14	97	149	189	214	913
5	7,542	2,654	3,483	1,526	374	46	15,625
6	30,282	18,739	5,683	906	120	5	55,735
7	7,935	3,607	2,746	1,244	419	91	16,042
8	299	420	481	829	1,072	362	3,463
Total	97,654	123,652	48,963	11,795	3,325	785	286,174

Table A1.3. Average Number of Beef Cows Per Beef Cow Herd, by Herdsize and Region, United States, 1975-76.

Region	Herdsize (Head)						
	1-19	20-49	50-99	100-199	200-499	500-999	1000 or more
	Head						
1	7.95	29.21	64.45	126.53	268.30	613.82	1,264.33
2	7.37	29.32	65.36	127.42	237.08	869.55	1,652.54
3	8.04	29.89	65.71	128.99	270.42	621.91	1,857.90
4	7.53	30.72	66.51	133.44	289.27	677.91	2,600.29
5	8.90	30.64	66.53	130.74	283.74	657.52	2,000.08
6	9.63	31.13	67.09	129.33	270.83	644.32	1,553.14
7	6.34	31.36	69.12	136.04	291.35	676.81	1,730.01
8	6.41	31.02	68.28	137.77	295.85	667.17	1,883.52

Table A1.4. Average Number of Dairy Cows Per Dairy Herd, by Herdsize and Region, United States, 1975-76

	Herdsize (Head)					
Region	1-19	20-49	50-99	100-199	200-499	500 or more
	-----Herd-----					
1	7.47	31.50	61.88	121.12	249.28	675.22
2	2.71	32.03	66.06	123.90	251.33	618.64
3	3.71	30.13	64.74	124.49	248.61	762.21
4	2.63	31.50	67.85	132.69	314.26	1,053.40
5	2.47	32.34	66.83	123.88	260.17	916.63
6	4.75	29.94	61.61	116.90	253.54	591.20
7	2.82	31.31	65.73	125.80	274.61	939.22
8	2.94	32.00	67.60	139.12	302.13	849.54

Proportion of Herds Purchased

Important to the simulation of a disease like brucellosis is the proportion of the herds that are purchased annually. This information was derived from the 1969 Census of Agriculture, Volume V, Special Reports, 1971. The proportion of herds purchased varied by beef and dairy herds and by region as indicated in Table A1.5.

The Source Ratio

The source ratio or the number of herds from which replacements are purchased is a significant variable in determining the spread of brucellosis. These data, which were obtained through a questionnaire to a random sample of beef and dairy producers in the eight regions in the model, are shown in Table A1.6.

Regional Purchase Probability

In addition to the source ratio, the proportion of purchased cattle obtained from various regions throughout the United States by beef and dairy producers is important in the spread and/or reintroduction of brucellosis within and among regions. The primary data source for estimating the geographic source of purchased beef and dairy replacements was the producer questionnaire to beef and dairy operators for 1974-76. Other data sources included a sample of state animal health inspection certificates for 1975 and 1976. The estimated geographic sources of purchased beef and dairy replacements, by region, are indicated in Tables A1.7 and A1.8, respectively.

Number of Infected Herds

Paramount to the NBTC brucellosis simulation model was an estimation of the total number of infected beef and dairy herds in the United States, by region, for 1976. The number of "known" infected herds can be readily compiled from U.S. Department of Agriculture (APHIS) records for the beef and dairy sectors. However, area testing and other information indicates that present testing and program procedures do not detect all infected herds. Thus, the number of known infected herds, were adjusted on a regional basis to account for the total number of infected herds. This regional herd infection expansion factor was developed after consultation with regional epidemiologists and field personnel of the U.S. Department of Agriculture, practicing veternarians, State Animal Health Commissions, and program records. The number of known infected herds, the regional expansion factor, and the estimated number of total infected herds by region for the beef and dairy sector

Table A1.5. Proportion of Beef and Dairy Herds Purchased, by Region, United States, 1969.

Region	Beef Cow Herds	Dairy Cow Herds
	----------Percent----------	
1	7.2	7.8
2	8.2	10.4
3	6.7	12.2
4	4.7	23.4
5	8.7	13.7
6	7.2	13.2
7	5.3	9.3
8	10.3	16.5

Table A1.6. The Number of Herds From Which Replacements were Purchased by Beef and Dairy Operators, by Herdsize, United States, 1974-76.

Herdsize (Head)	Beef Cow Herds	Dairy Cow Herds
	----------Number----------	
1-19	1.46	2.40
20-40	2.86	2.70
50-99	2.94	3.18
100-199	3.20	3.80
200-499	3.12	8.87
500-999	2.16	8.87
1000 or more	1.80	--

Table A1.7. Geographic Sources of Purchased Beef Herd Replacements, by Region, United States, 1974-76.

Receiving Region	Geographic Source (Region)								
	1	2	3	4	5	6	7	8	Total
	Percent								
1	78.7	.7	1.6	.1	1.1	16.4	1.4	NR	100.0
2	3.6	89.6	3.7	.4	.2	.6	1.9	NR	100.0
3	.1	.2	70.0	.2	28.3	.8	.4	NR	100.0
4	NR	NR	5.5	91.7	2.8	NR	NR	NR	100.0
5	.4	NR	.1	.2	89.4	2.2	7.7	NR	100.0
6	.6	NR	3.5	NR	8.8	76.5	9.5	1.1	100.0
7	NR	NR	NR	NR	6.0	6.0	86.5	1.5	100.0
8	1.3	NR	NR	NR	2.0	3.1	29.3	64.3	100.0

NR - None Reported.

Table A1.8. Geographic Sources of Purchased Dairy Herd Replacements, by Region, United States, 1974-76.

Receiving Region	Geographic Source (Region)								
	1	2	3	4	5	6	7	8	Total
	Percent								
1	82.5	1.2	5.0	NR	NR	11.3	NR	NR	100.0
2	28.9	67.7	3.3	NR	NR	.1	NR	NR	100.0
3	25.6	.1	59.1	7.4	7.5	.3	NR	NR	100.0
4	58.5	4.4	27.5	7.8	.4	1.2	.2	NR	100.0
5	6.4	NR	4.3	NR	69.6	17.7	.7	1.3	100.0
6	11.3	NR	10.6	NR	.2	77.9	NR	NR	100.0
7	16.4	NR	NR	NR	.4	3.2	78.8	1.2	100.0
8	.2	NR	NR	NR	.8	.4	17.0	81.6	100.0

NR - None Reported.

for 1976 are shown in Tables A1.9 and A1.10, respectively.

<u>MCI and BRT Surveillance Rates</u>

The MCI survelliance effeciency rates vary by region depending upon the efforts, expenditures, and program effeciency as a result of the combined efforts of federal, state and local governments and the cooperation of herd owners and others associated with the cattle industry. The MCI and BRT regional surveillance effeciency rates shown in Table A1.11 were developed after examining program records and after developing sensitivity tests to stabilize herd infection rates for the base model.

These MCI surveillance effeciency rates were applied to all models with the exception of the Accelerated - 1 and Accelerated - 2 models. It was assumed that region 3 moved into the accelerated program by 1977 (year 1 in the model), region 5 moved in by 1980 (year 4) and region 4 moved in by 1982 (year 6) and that one-third of each region would be tested per year. This affected the MCI surveillance effeciency rates in regions 3, 4, and 4 as follows:

<u>Accelerated - 1 Model</u>

A. It was assumed that FPC (first point of concentration testing) began one year prior to the area testing and increased the existing regional MCI rates by .150.

B. The MCI surveillance efficiency coefficient was increased an additional .0667 per year, for a total increase of .200 over the three years of area testing in addition to the .150 increase due to FPC.

C. The MCI surveillance effeciency coefficient was assumed to remain .100 above the levels existing prior to area testing after area testing was completed and remained at this high level throughout the remaining years of accelerated - 1 program.

<u>Accelerated - 2 Model</u>

A. All of the above assumptions hold except that FPC remained in effect for two years after area testing, increasing the MCI surveillance effeciency coefficient by .100 above the regional levels existing prior to area testing. After FPC was terminated, it was assumed that the MCI surveillance effeciency coefficient dropped to the regional levels existing prior to area testing.

Table A1.9. Estimated Total Infected Beef Herds, by Region, United States, 1976.

Region	Known Infected Herds	Regional Expansion Factor	Total Estimated Infected Herds
	Herds	Expansion Factor	Herds
1	175	1.7	298
2	44	1.7	75
3	3,055	2.8	8,544
4	496	3.5	1,736
5	6,748	3.3	22,268
6	649	2.75	1,785
7	365	2.0	730
8	29	1.5	44

Table A1.10. Estimated Total Infected Dairy Herds, by Region, United States, 1976.

Region	Known Infected Herds	Regional Expansion Factor	Total Estimated Infected Herds
	Herds	Expansion Factor	Herds
1	99	1.3	129
2	9	1.3	12
3	302	1.3	393
4	72	1.3	94
5	197	1.3	256
6	53	1.3	69
7	52	1.3	68
8	16	1.3	21

Table A1.11. Estimated MCI and BRT Surveillance Efficiency Rates, by Region, United States, 1976.

Region		BRT
	---------------- Coefficient----------------------------	
1	.700	.800
2	.750	.800
3	.525	.800
4	.500	.800
5	.510	.800
6	.650	.800
7	.650	.800
8	.700	.800

Vaccinal Protection Effectiveness

Vaccinal protection effectiveness, which varies by herd vaccination levels, was developed by the Commission after exhaustive studies of available research data from various sources. The assumed vaccinal protection effectiveness, including the vaccinal protection ineffectiveness, by herd vaccination levels, are shown in Table A1.12.

Herd Infection Rates

Estimated herd infection rates, by year of infection, were developed for the beef and dairy sector for the existing (base) program for each region. These infection rates were developed from existing program records and upon consultation with regional epidemiologists and field personnel of the U. S. Department of Agriculture. Estimated herd infection rates within infected beef and dairy herds for the base program are shown in Tables A1.13 and A1.14. Herd infection rates in Tables A1.13, and A1.14 were adjusted (multiplied) by the vaccinal protection ineffectiveness, by herd vaccination levels, shown in Table A1.12 to reflect infection rates for herds with vaccination levels of 90 percent or higher, 60-89 percent and 20-59 percent.

Clean-up Rates

Clean-up rates or the length of time detected herds remain under quarantine varies by herdsize, herd density, regional management practices, etc. The cumulative percent of quarantined herds released from quarantine within 12 months, 13 to 24 months, and more than 24 months for quarantined beef and dairy herds are indicated in Tables A1.15 and A1.16, respecitvely, for the base program during 1975-76. Both the clean-up rates in Tables A1.15 and A1.16 and the number of tests required to clean-up herds (Table 34) were adjusted by the following factors depending upon herd vaccination levels as follows: 20-59 percent by .95, 60-90 percent by .80 and 90 percent of higher by .55. Clean-up rates for undetected herds were assumed to occur primarily as a result of herd management culling practices.

Community Spread Factor

The community or neighborhood spread factor is the probability of herds in the same proximity becoming infected as the result of an infected herd. These coefficients were developed based upon consultation with regional epidemiologists, field personnel and program records. The community or neighborhood spread coefficients, which are affected by regional herd management practices, regional herd density,

Table A1.12. Estimated Vaccinal Protection Effectiveness and Vaccinal Protection Ineffectiveness, by Herd Vaccination Levels.

Herd Vaccination Levels (percent)	Vaccinal Protection Effectiveness	Vaccinal Protection Ineffectiveness
	Percent	
90 or Higher	70.4	29.6
60 - 89	56.0	44.0
20 - 59	34.0	66.0
Under 20	0	100.0

Table A1.13. Estimated Brucellosis Infection Rates Within Infected Beef Herds, by Region, Year of Infection, and Herdsize, Base (current) Program, United States, 1975-76.

Herd Size (Head)	Region One			Region Two			Region Three			Region Four		
	1*	2*	3*	1*	2*	3*	1*	2*	3*	1*	2*	3*
	Infection Levels (Percent)											
1-19	31.0	40.0	50.0	25.0	30.0	36.6	27.6	30.0	37.0	27.5	30.0	38.5
20-49	17.2	30.0	40.0	16.0	24.0	30.0	19.5	27.0	35.0	18.5	26.0	30.0
50-99	7.8	12.0	35.0	7.6	12.0	24.0	9.5	15.0	26.0	10.0	17.0	25.0
100-199	5.6	10.0	27.0	5.6	10.0	20.0	7.5	12.0	22.0	8.5	11.0	21.0
200-499	2.7	10.0	20.0	2.9	9.5	10.0	6.0	10.0	19.0	7.9	14.0	20.0
500-999	1.8	8.0	10.0	2.0	8.0	14.0	2.5	10.0	14.0	3.0	13.0	18.0
1000 or more	1.0	6.0	10.0	1.0	6.0	10.0	1.0	7.0	10.0	1.0	9.5	18.0

*Denotes Year of Infection

Table A1.13. Estimated Brucellosis Infection Rates (continued)

Herd Size (Head)	Region Five			Region Six			Region Seven			Region Eight		
	1*	2*	3*	1*	2*	3*	1*	2*	3*	1*	2*	3*
	Infection Levels (Percent)											
1-19	28.0	30.0	38.0	25.0	29.5	36.5	26.1	30.0	39.3	26.20	26.20	39.30
20-49	17.0	27.0	30.0	16.5	26.5	29.5	12.0	25.0	25.0	30.0	6.7	28.0
50-99	9.5	16.0	25.0	9.0	15.0	24.5	6.0	13.0	22.5	4.4	1.2	20.0
100-199	7.0	13.0	20.0	6.5	12.5	20.0	4.5	11.0	18.0	2.9	9.0	16.0
200-499	6.5	15.0	22.5	4.5	11.0	18.0	3.0	9.0	15.0	2.6	6.7	13.0
500-999	2.2	14.0	19.0	2.0	9.5	13.0	1.9	5.0	10.0	1.9	4.0	10.0
1000 or more	1.0	12.5	15.0	1.0	6.5	10.0	1.0	4.0	10.0	1.0	3.0	10.0

*Denotes Year of Infection

Table A1.14. Estimated Brucellosis Infection Rates Within Infected Dairy Herds, by Region, Years of Infection, and Herdsize, Base (current) Program, United States, 1975-76.

Herd Size (Head)	Region One			Region Two			Region Three			Region Four		
	1*	2*	3*	1*	2*	3*	1*	2*	3*	1*	2*	3*
	Infection Levels (Percent)											
1-19	26.1	39.2	55.0	28.8	43.3	55.0	26.3	39.4	55.0	37.1	44.6	55.0
20-49	9.3	27.9	52.0	9.1	24.4	52.0	9.7	29.1	52.0	9.3	27.9	52.0
50-99	6.3	26.8	50.0	5.1	22.0	50.0	5.2	24.1	50.0	7.2	24.4	50.0
100-199	4.8	24.2	50.0	3.1	21.3	50.0	3.9	22.7	50.0	3.6	20.6	50.0
200-499	4.0	20.0	47.0	2.9	17.8	47.0	3.0	18.0	47.0	2.3	20.0	50.0
500-999	4.0	20.0	47.0	2.9	17.8	47.0	3.0	18.0	47.0	2.3	20.0	50.0

*Denotes Year of Infection

Table A1.14. Estimated Brucellosis Infection Rates (continued)

(Head)	Region Five			Region Six			Region Seven			Region Eight		
	1*	2*	3*	1*	2*	3*	1*	2*	3*	1*	2*	3*
	Infection Levels (Percent)											
1-19	31.6	39.5	55.0	20.5	37.0	55.0	34.6	44.9	55.0	--	--	55.0
20-49	9.0	27.1	52.0	9.7	29.3	52.0	9.3	28.0	52.0	3.0	15.2	52.0
50-99	5.8	23.3	50.0	6.3	26.9	50.0	5.9	25.2	52.0	4.3	11.5	50.0
100-199	3.9	22.0	50.0	4.1	22.5	50.0	3.8	24.0	50.0	2.8	8.4	50.0
200-499	2.0	17.1	47.0	2.9	18.6	47.0	1.5	16.0	47.0	1.3	6.6	50.0
500-999	2.0	17.1	47.0	2.9	18.6	47.0	1.5	16.0	47.0	1.3	6.6	50.0

*Denotes Year of Infection

Table A1.15. Clean-up Rates, Cumulative Percent by Months, Quarantined Beef Herds, by Region and Herdsize, Base Program, United States, 1975-76

Region and Herd Size	Months 12	13-24	24+	Region and Herd Size	Months 12	13-24	24+
Region 1	Percent			Region 5	Percent		
1-19	90	100	-	1-19	96	100	-
20-49	90	100	-	20-49	84	100	-
50-99	85	100	-	50-99	60	99	100
100-199	75	95	100	100-199	60	92	100
200-499	70	90	100	200-499	45	85	100
500-999	60	90	100	500-999	40	80	100
1000 +	60	90	100	1000 +	40	80	100
Region 2	Percent			Region 6	Percent		
1-19	90	100	-	1-19	80	100	-
20-49	85	100	-	20-49	80	100	-
50-99	75	100	-	50-99	70	100	-
100-199	60	95	100	100-199	60	95	100
200-499	50	90	100	200-499	45	90	100
500-999	50	90	100	500-999	40	90	100
1000 +	50	90	100	1000 +	40	90	100
Region 3	Percent			Region 7	Percent		
1-19	95	100	-	1-19	65	100	-
20-49	73	95	100	20-49	65	100	-
50-99	69	92	100	50-99	60	90	100
100-199	50	88	100	100-199	50	85	100
200-499	50	88	100	200-499	46	85	100
500-999	50	88	100	500-999	40	80	100
1000 +	50	88	100	1000 +	40	75	100
Region 4	Percent			Region 8	Percent		
1-19	100	-	-	1-19	-	-	
20-49	95	100	-	20-49	100	-	
50-99	85	100	-	50-99	80	100	
100-199	80	95	100	100-199	60	100	
200-499	70	90	100	200-499	55	100	
500-999	53	85	100	500-999	40	100	
1000 +	50	85	100	1000 +	30	90	100

Table A1.16. Clean-up Rates, Cumulative Percent, by Months, Quarantined Dairy Herds, by Region and Herdsize, Base Program, United States, 1975-76.

Region and Herd Size	Months 12	13-24	24+	Region and Herd Size	Months 12	13-24	24+
Region 1	Percent			Region 5	Percent		
1-19	100	-	-	1-19	90	100	-
20-49	90	100	-	20-49	90	100	-
50-99	70	100	-	50-99	70	100	-
100-199	60	95	100	100-199	60	95	100
200-499	55	90	100	200-499	55	90	100
500 +	45	85	100	500 +	45	85	100
Region 2	Percent			Region 6	Percent		
1-19	90	100	-	1-19	90	100	-
20-49	90	100	-	20-49	80	100	-
50-99	70	95	100	50-99	70	90	100
100-199	60	90	100	100-199	70	90	100
200-499	55	85	100	200-499	70	90	100
500 +	-	-	-	500 +	-	-	-
Region 3	Percent			Region 7	Percent		
1-19	90	100	-	1-19	100	-	-
20-49	90	100	-	20-49	90	100	-
50-99	70	95	100	50-99	80	100	-
100-199	60	90	100	100-199	60	95	100
200-499	55	85	100	200-499	55	90	100
500 +	-			500 +	-		
Region 4	Percent			Region 8	Percent		
1-19	100	-	-	1-19	100	-	-
20-49	100	-	-	20-49	100	-	-
50-99	100	-	-	50-99	100	-	-
100-199	70	100	-	100-199	100	-	-
200-499	30	50	65	200-499	77	86	100
500 +	10	20	30	500 +	61	83	100

regional fencing practices, etc. are shown in Table A1.17. The coefficients in Tables A1.17 are affected by both herd vaccination levels and quarantine status. In this study, it was assumed that whenever an infected herd moved from an undetected to a detected (quarantine) status, that regional community spread coefficients were reduced by 50 percent. In addition, regional community spread coefficients were adjusted (multiplied) to reflect vaccinal protection ineffectiveness as follows: 90 percent or higher by .296, 60-89 percent by .440 and 20-49 percent by .660.

Residual Infection Coefficients

Field experiences and program records indicate that some of the infected herds which were released from quarantine status were returned to a quarantine status and in the interim had not purchased replacements and also were not reinfected through community spread. The Commission felt that residual infection was of significant magnitude to affect the spread and/or eradication of brucellosis and developed residual infection coefficients by herdsize and region for inclusion in the simulation model. These coefficients are shown in Table A1.18 for beef and dairy herds. It was also assumed that residual infection coefficients were influenced by the vaccinal protection ineffectiveness and were adjusted for the various herd vaccination levels as follows: 90 percent or higher by .296, 60-89 percent by .440 and 20-59 percent by .660.

Cull Rates

The standard culling rate for the dairy industry was assumed to be .281 as reported in a recent study, Costs of Producing Milk in the United States, 1975 and 1976, Senate Committee on Agriculture and Forestry, U. S. Congress.

The average beef cow culling rate over the cattle cycle was assumed to be .1667. However, an overall culling rate of .20 was used in the model to account for the cows culled and breeding cattle which were subjected to the market surveillance system but were added as herd replacements. Further, the overall beef culling rate was adjusted to reflect culling rates during various phases of the cattle cycle as follows with year 1 representing the peak of the cattle cycle:

Table A1.17. Community Spread Coefficients, by Region, Beef and Dairy Cow Herds, Undetected Infected Herds, Base Program, United States, 1975-76.

Region	Beef	Dairy
	---------- Coefficient ----------	
1	.30	.10
2	.30	.10
3	.20	.15
4	.20	.12
5	.20	.10
6	.17	.08
7	.12	.06
8	.10	.05

Table A1.18. Residual Infection Coefficients, by Region and Herdsize, Beef and Dairy Cow Herds, Base Program, United States, 1975-76.

Herdsize and Item	Region 1	2	3	4	5	6	7	8
	Coefficient							
BEEF:								
1-19	.010	.010	.100	.050	.090	.010	.010	.010
20-49	.010	.030	.150	.050	.120	.010	.030	.010
50-99	.020	.050	.150	.150	.150	.050	.050	.010
100-199	.020	.050	.150	.260	.150	.100	.050	.030
200-499	.030	.030	.150	.200	.100	.100	.100	.100
500-999	.020	.020	.150	.100	.060	.050	.050	.030
1000 or more	.020	.020	.150	.050	.020	.020	.020	.030
DAIRY:								
1-19	.010	.010	.050	-	.050	.010	.010	-
20-49	.050	.010	.050	.050	.060	.050	.030	.010
50-99	.080	.030	.070	.100	.100	.070	.050	.050
100-199	.030	.030	.070	.100	.110	.080	.070	.070
200-499	.010	.030	.100	.100	.120	.050	.050	.100
500+	.010	.030	.050	.050	.050	.010	.010	.050

Year of Cycle	Beef Cow Cull Rate (Percent)
1	.2360
2	.2235
3	.2068
4	.2004
5	.1926
6	.1664
7	.1768
8	.1584
9	.1580
10	.2077

These culling rates during the various phases of the beef cattle cycle reflect changes in beef cow numbers over the last two cattle cycles relative to annual beginning and ending inventories, cow slaughter, replacement rates, and death rates as reported in Livestock and Meat Statistics, U. S. Department of Agriculture.

Regional Quality Control Factor

The effort put forth by state and local governmental agencies, producers and others associated with the cattle industry to control and/or eradicate brucellosis is of major importance to the success of the program. The estimated quality control coefficients, by region, for the beef cattle industry were as follows with 1.0 reflecting a 100 percent cooperative effort by all parties concerned: region 1, .850; region 2, .900; region 3, .800; region 4, .650; region 5, .725; region 6, .825; region 7, .775; and region 8, .900. These regional quality control coefficients remained in effect for all program models with the exception of the accelerated program series. In the Accelerated - 1 model, the regional quality control coefficients were assumed to increase 10 percent in region 4, 7.5 percent in region 5, and 5 percent in region 3 during area testing and also remained at these higher levels during the remaining years of the Accelerated - 1 program. In the Accelerated - 2 model, the regional quality control coefficients were increased as indicated above, but it was assumed that the regional quality control factors dropped back to the levels existing prior to area testing after FPC programs were completed two years after the completion of area testing in regions 3, 4, and 5.

Annex 2 - Copies of Questionnaires to Beef Producers and Dairymen

BRUCELLOSIS BEEF CATTLE

MANAGEMENT AND HANDLING QUESTIONNAIRE

I. General Information:

A. Please indicate in which state(s) your cow-calf operation is located. ________________________________.

B. Please estimate the following with regard to your cattle operation for 1976:

1. Total acres used for cattle grazing ______________ (acres).

a. Is all acreage in adjoining pastures? Yes ____, No ____.
b. If no, how many locations are involved? ______________.

2. Please estimate the number of pastures in your total cattle operation. ____________________.

3. How often do you move cattle from one pasture to another during the year? _________________________.

4. In what seasons do you normally calve? (Please check.)
Fall____, Winter____, Spring____, Summer____, Year round____.

II. Please Estimate Your Beef Cattle Inventory and Related Information as Follows:

A. Cows and heifers that have calved ____________________(number).

B. Replacement heifers (8 months and older that have not calved) ________________ (number).

C. Average percent weaned calf crop for the last 3 years ________%.

D. Number of replacement heifers added to your herd for the following years: 1974 __________, 1975 __________, 1976 __________.

1. What percent of these replacements were: home-raised______%, purchased_______%.

III. Cow Purchases:

A. Please indicate the number of replacement cows purchased in each of the last 3 years: 1974_______, 1975_______, 1976_______.

B. What percent of these purchased cows were tested for Brucellosis immediately prior to delivery? ___________________.

1. If you tested cows for Brucellosis prior to delivery, please indicate the cost per cow to have them tested. $___________.

C. Do you keep purchased replacement cows isolated from the remainder of the herd for 30 to 60 days? Yes _____, No _____.

1. If yes, do you retest cows for Brucellosis prior to placing them with the remainder of the herd? Yes ______, No _______.

a. If yes, what is the cost per cow to retest? $___________.

IV. Source of Purchased Breeding Cows or Heifers During the Last Three Years:

A. Please indicate the number of breeding cows and replacement heifers that were purchased from the following sources during the last 3 years.

	1974	1975	1976
Dealers	______	______	______
Public Markets	______	______	______
Individual Ranchers	______	______	______
Other (specify)	______	______	______

B. Of those replacements purchased in the last 3 years, how many originated in:

	1974	1975	1976
Your County	______	______	______
Your State (outside your county)	______	______	______
Out-of-State	______	______	______
Unknown	______	______	______

1. Please indicate the number of replacement purchases, by state, for all out-of-state purchased (if possible) during 1974, 1975 and 1976. ____

____.

2. Please estimate, if possible, the number of herds your purchased beef cows or replacement heifers originate from during a typical year, cows ________(herds); heifers __________(herds). (NOTE: each purchase, even though from the same herd during the year, should be considered a separate herd.)

V. Vaccination Program:

A. What percent of your cow herd is currently vaccinated against Brucellosis? _______________%.

B. How many of your total heifer calf crop were vaccinated against Brucellosis in 1974 __________, 1975 ___________, 1976 ________?

C. How many of your home-raised vaccinated heifers did you keep as replacements in 1974__________, 1975____________, 1976_________?

D. What percent of your purchased heifer and cow replacements were calfhood vaccinated during 1974-76? Heifers______%, Cows______%.

VI. Labor and Cost Requirements for Brucellosis Roundups, Testing (Collecting Blood), and Calfhood Vaccination:

A. General information:

1. Has your herd ever been tested for Brucellosis? Yes___, No___.

2. Has your herd ever been quaratined because of Brucellosis? Yes____, No_____.

a. If yes, when? ______________________________
b. What percent reactors did you have on the initial test? ____________%.

3. What length of time did it take to clean up your herd? _____(months) and how many tests? _________

B. Cattle Roundups

1. Man hours and wage rates required per roundup:

a. Owner ______(hours) Hourly wage rate $________/hour

b. Manager ______(hours) Hourly wage rate $________/hour

c. Others ______(hours) Hourly wage rate $________/hour

2. Please indicate any additional costs per roundup for hiring and/or leasing additional horses, vehicles, and equipment. (Indicate type, number and costs for each.) ____________

____

____

____

3. Please estimate the total costs incurred per roundup for furnishing your own horses and/or equipment. $____________

C. Labor requirements for testing cows for Brucellosis: (chute work and catching cows and bulls to collect blood)

1. Number of man hours required:

a. Owner __________(hours)

b. Manager __________(hours)

c. Others __________(hours)

D. Labor requirements for Brucellosis vaccination: (separating, catching, and vaccinating of heifer calves)

1. Would you or do you have to make a special roundup to vaccinate heifer calves against Brucellosis? Yes____, No____

2. Number of man hours required for vaccination:

a. Owner _________(hours) Hourly wage rate $_____/hour

b. Manager _________(hours) Hourly wage rate $_____/hour

c. Others _________(hours) Hourly wage rate $____/hour

VII. Working Facilities Available for Testing Cattle and Vaccinating Heifer Calves:

A. Equipment of premise:

1. Do you own a squeeze chute? Yes ____, No _____.

a. If yes, indicate type of squeeze chute: Manual _____ or Hydraulic _____.

2. Do your facilities also include:

   a. A crowding alley? Yes _______, No _______
   b. A headgate? Yes _______, No _______

3. If your facilities do not include a squeeze chute or headgate, do you rent such equipment? Yes _______, No _______

   a. If yes, please indicate the cost per day or hour. (specify)

      $_________________

BRUCELLOSIS DAIRY CATTLE
MANAGEMENT AND HANDLING QUESTIONNAIRE

I. General Information:

A. Please indicate in which state(s) your dairy operation(s) is located. ______________________________

B. Please indicate the following with regard to your dairy operation:

1. Type of operation (please check):

a. Dry lot (year round) ____________

b. Pasture ____________

c. Other (specify) ____________

2. Type of housing (please check):

a. Covered free stall ____________

b. Open free stall ____________

c. Stanchion barn ____________

d. Other (specify) ____________

3. Type and size of milking equipment:

	Type of Milking Parlor	Size (cow capacity)
a. Herringbone	__________	____________
b. Side-opening	__________	____________
c. Stanchion	__________	____________
d. Other (specify)	__________	____________

II. Please estimate your dairy cattle inventory for 1976 as follows:

A. Cows and heifers that have calved ______________(number).

B. Average number of lactating cows during the year _______(number).

C. Please estimate your average herd level of milk production per cow per year ______________(pounds).

III. Replacement and Source Information:

A. Please indicate the number of cows and heifer replacements added to your herd for the following years:

Cows - 1974__________, 1975__________, 1976__________

Heifers - 1974__________, 1975__________, 1976__________

B. What percent of the above cow and heifer replacements were purchased (not home-raised) during the following years:

Cows - 1974________%, 1975________%, 1976________%

Heifers - 1974________%, 1975________%, 1976________%

C. Please estimate the average price per head paid for cows and heifer replacements during the following years:

Cows - 1974 $________, 1975 $________, 1976 $________

Heifers - 1974 $________, 1975 $________, 1976 $________

D. Please estimate, if possible, the number of herds from which your your purchased dairy cow or replacement heifers originate during a typical year:

cows________(herds); heifers________(herds). (NOTE: each purchase even though from the same herd during the year should be considered a separate herd.)

E. Please indicate the number of cows and replacement heifers that were purchased from the following sources during the last 3 years:

	1974	1975	1976
Local or consignment sales	________	________	________
Public markets	________	________	________
Dealers	________	________	________
Individual Producers	________	________	________
Other (specify)	________	________	________

F. What percent of your purchased dairy cow or heifer replacements originated from sources within your state during the last three years? ________%

1. If purchased replacements originated from out-of-state, please indicate the number of purchases by originating state(s) if possible, during the last three years. ________

____

____

IV. Vaccination Program:

A. What percent of your milking herd is currently vaccinated against Brucellosis? ________%

B. What percent of your home-raised dairy heifer calves are vaccinated against Brucellosis annually? ________%

C. What percent of your replacement heifers were vaccinated against Brucellosis during the last 3 years? ____________%

D. What percent of your purchased replacements were vaccinated against Brucellosis? ____________%

V. Brucellosis Testing and Associated Costs:

A. Have you ever blood tested your dairy herd for Brucellosis?

Yes ______, No ______

B. Have you ever been quarantined for Brucellosis testing?

Yes ______, No ______

1. If yes, when? ______________________________

C. Please estimate the labor requirements associated with testing dairy cattle for Brucellosis (chute work, catching cows and bulls to collect blood) and hourly wage rates related to your dairy operation:

Type of Labor	Hours	Wage Rate/Hour
Owner	________	________
Manager	________	________
Others	________	________

ANNEX 3

PROCEDURES FOR ESTIMATING COEFFICIENTS TO DETERMINE PHYSICAL LOSSES PER INFECTED BEEF COW

In order to determine the total physical and/or economic losses per infected beef cow, it was necessary to estimate the percentage of infected beef cows that (1) have dead calves, (2) have delayed conception or are open, (3) have decreased beef production because of weak calves or inadequate milk production, and (4) are culled as a result of the disease. These losses will vary depending upon culling practices, levels of vaccination, and whether infected herds are identified (quarantined) or are unidentified as shown in Tables 3 and 4.

The following is an example of how the percentage of infected cows were estimated for each selected loss category, by year of infection, for region 1 in Table 3. The basic input data for determining those losses are shown in Tables 1 and 2. The percentage of infected cows to be included in each selected loss cateogry, by year of infection, were computed as follows for Region 1 in unvaccinated and undetected herds:

<u>Culled</u>

<u>Year 1</u> = (.60) (.80) + (.40) (.30) (.55) = .5460

where

60.0 = percent infected cows aborting in the first year of infection,

80.0 = percent of aborters culled,

40.0 = percent of non-aborting cows in the first year of infection,

30.0 = percent of non-aborting cows culled in the first year of infection,

55.0 = percent of non-aborting cows with weak calves and decreased milk production in the first year of infection.

<u>Year 2</u>

Since producers do not cull all infected cows in unidentified herds, non-culled infected cows were carried over into the year 2 infection category.

Carryovers from Year 1 = 1 - .5460 = .4540

Newly infected in Year 2 = 2[1/] - .4540 = 1.5460

The culling rates within herds in the second year of infection are:

Year 1 carryovers = [.4540] [(.05) (.80) + (.95) (.25) (.33)] = .0537

Newly infected cows = [1.546] [(.60) (.80) + (.40) (.30) (.55)] = .8441

The culling rate is $\frac{.0537 + .8441}{2}$ = .4489

where

5.0 = percent infected cows aborting in the second year of infection,

80.0 = percent of aborters culled,

95.0 = percent of non-aborting cows in the second year of infection,

25.0 = percent of non-aborting cows culled in the second year of infection,

33.0 = percent of non-aborting cows with weak calves, decreased milk production, and slow breeders in the second year of infection and the other variables have been previously identified.

[1/] Procedures for determining the precise effect of replacements into an infected herd and the effective infection rate of such replacements and all additions over a number of years is a complex process. The procedure adopted for this study is as follows. The culling coefficient for year 1 infected herds in region 1 was .5460 as indicated above. Therefore, the infection coefficient representing the carryovers from year 1 to year 2 is 1 - .5460 = .4560. The procedure for deriving the infection coefficient for the newly infected cows in year 2 is 2 - .4540 = 1.546. Therefore the infection coefficients .4540 representing carryovers from year 1 and 1.546 representing newly infected animals sum up to 2. The infection coefficients were multiplied by their respective loss coefficients in Tables 1 and 2 as shown above, the products summed, and divided by 2 to normalize the summed product which is the culling coefficient (.4489) in year 2. A similar procedure was used for herds moving into the third year of infection.

Year 3

Carryovers from Year 1 = .4540 - .0537 = .4003

Carryovers from Year 2 = 1.546 - .8441 = .7019

Newly infected cows = 2 - .4003 - .7019 = .8978

The culling rates within herds in the third year of infection are:

Carryovers from Year 1 = [.4003] [(.01) (.80) + (.999) (.20) (.23)] = .0187

Carryovers from Year 2 = [.7019] [(.05) (.80) + (.95) (.25) (.33)] = .0831

Newly infected cows = [.8978] [(.60) (.80) + (.40) (.30) (.55)] = .4902

The culling rate is $\frac{.0187 + .0831 + .4902}{2} = .2960$

where

0.1 = percent infected cows aborting in the third year of infection,

80.0 = percent of aborters culled,

99.9 = percent of non-aborting cows in the third year of infection,

20.0 = percent of non-aborting cows culled in the third year of infection,

23.0 = percent of non-aborting cows with weak calves, decreased milk production, and slow breeders in the third year of infection and the other variables have been previously identified.

Have Dead Calves

Year 1 = (.60) + (.40) (.30) (.10) + (.40) (.25) (.10) = .6220

where

60.0 = percent of infected cows aborting in the first year of infection,

40.0 = percent of non-aborting cows in the first year of infection,

30.0 = percent of non-aborting cows with weak calves in the first

year of infection,

10.0 = death loss as a result of weak calves,

25.0 = percent of non-aborting cows with decreased milk production,

10.0 = death loss as a result of decreased milk production.

Year 2

Year 1 carryovers = [.4540] [(.05) + (.95) (.06) (.10) + (.95) (.12) (.10)] = .0305

Newly infected cows = [1.5460] [(.60) + (.40) (.30) (.10) + (.40) (.25) (.10)] = .9616

Cows with dead calves = $\frac{.0305 + .9616}{2}$ = .4960

where

.4540 = non-culled cows carried over from year 1,

5.0 = percent aborting in the second year of infection,

95.0 = percent of non-aborters in the second year of infection,

6.0 = percent of non-aborters with weak calves in the second year of infection,

12.0 = percent of non-aborters with decreased milk production in the second year of infection and the other variables have been previously identified.

Year 3

Year 1 carryovers = [.4003] [(.001) + (.999) (.03) (.10) + (.999) (.10) (.10)] = .0056

Year 2 carryovers = (.7019] [(.05) + (.95) (.06) (.10) + (.95) (.12) (.10)] = .0471

Newly infected cows = [.8979] [(.60) + (.40) (.30) (.10) + (.40) (.25) (.10)] = .5585

Cows with dead calves = $\frac{.0056 + .0471 + .5585}{2}$ = .3056.

where

.4003 = non-culled cows carried over from year 1,

3.0 = percent of non-aborters with weak calves in the third year of infection,

10.0 = percent of non-aborters with decreased milk production in the third year of infection and the other variables have been previously identified.

Have Lower Weight Calves

Year 1 = (.40) (.30) (.90) + (.40) (.25) (.90) = .1980

where

40.0 = percent of non-aborting cows in the first year of infection,

30.0 = percent of non-aborters with weak calves,

90.0 = percent of weak calves reaching weaning age,

25.0 = percent of non-aborters with decreased milk production and the other variables have been previously identified.

Year 2

Year 1 carryovers = [.4540] [(.95) (.06) (.90) + (.95) (.12) (.90)] = .0699.

Newly infected cows = [1.5460] [(.40) (.30) (.90) + (.40) (.25) (.90)] = .3061.

Cows with lower weight calves = $\frac{.0699 + .3061}{2}$ = .1880.

where

.4540 = non-culled cows carried over from year 1,

95.0 = percent of non-aborting cows in the second year of infection,

6.0 = percent of non-aborting cows with weak calves in the second year of infection,

90.0 = percent of weak calves reaching weaning age,

12.0 = percent of non-aborting cows with decreased milk production in the second year of infection and the other variables have been previously identified.

Year 3

Year 1 carryovers = [.4003] [(.999) (.03) (.90) + (.999) (.10) (.90)] = .0468

Year 2 carryovers = [.7019] [(.95) (.16) (.90) + (.95) (.12) (.90)] = .1080

Year 3 carryovers = [.8979] [(.40) (.30) (.90) + (.40) (.25) (.90)] = .1778

Cows with lower weight calves = $\frac{.0468 + .1080 + .1778}{2}$ = .1663

where

.4003 = non-culled cows carried over from year 1,

99.9 = percent of non-aborting cows in the third year of infection,

3.0 = percent of non-aborting cows with weak calves in the third year of infection,

90.0 = percent of weak calves reaching weaning age,

10.0 = percent of non-aborters with decreased milk production and the other variables have been previously identified.

Delayed Conception or Open

Year 1 = 0 as delayed conception or unbred cows is not applicable until after the first year of infection.

Year 2 = [.4540] [(.95) (.15)] = .0647

where

.4540 = non-culled cows carried over from year 1,

95.0 = percent of non-aborting cows in the second year of infection,

15.0 = percent of non-aborting cows that are slow breeders or open in the second year of infection.

Year 3

Year 1 carryovers = [.4003] [(.999) (.10)] = .0400

Year 2 carryovers = (.7019] [(.95) (.15)] = .1000

$$\text{Delayed conception or open} = \frac{.0400 + .1000}{2} = .0700$$

where

.4003 = non-culled cows carried over from year 1,

99.9 = percent of non-aborting cows in the third year of infection,

10.0 = percent of non-aborting cows that are slow breeders or open in the third year of infection.

Losses per infected unvaccinated and detected beef cow were computed similar to those for the unvaccinated and undetected herds as shown in Table 4. However, for detected herds it was assumed that one-half of the infected cows were detected prior to aborting or exhibiting effects of physical losses in non-aborting cows. In addition, it was also assumed that herd owners in detected herds generally do not add replacements to infected herds prior to cleaning-up the herd. Therefore, the selected loss categories per infected beef cow in Table 4 were computed directly from Table 1 without allowing for adjustments due to the addition of replacements. The procedures used in calculating physical losses were similar to those described in Chapter III with the following exception. Since infected cows can be detected anytime prior to weaning a calf, it was assumed that calves reach about 40 percent of their marketing weight prior to detection of the infected nurse cow which results in a 60 percent normal marketing weight loss. This assumes that calves from detected cows are marketed at the same time as their nurse cows.

Annex 4

ESTIMATING PROCEDURES FOR CONVERTING WEANED CALF AND VEAL CALF LOSSES TO WHOLESALE CARCASS WEIGHTS

In order to estimate the effect of brucellosis on beef and veal supplies at the consumer level, it was necessary to convert the total annual pounds of weaned beef and veal calf death losses at the producer level to carcass beef and veal at the consumer level. For the beef sector, this was accomplished by estimating the disposition of beef calves in the beef industry as shown in Table 1. The disposition of dairy calves was estimated as shown in Table 2, below.

The average dressed steer-heifer weight at Federally Inspected slaughter plants from January, 1978, to May, 1978, was 635.63 pounds as reported by the U.S. Department of Agriculture in Livestock Slaughter, June, 1978. The live weaned beef calf conversion factor to a steer-heifer carcass weight is:

$$\frac{(635.63)}{408} \times (.745) = 1.160648$$

where:

635.63 = January-May 1978 U.S. average Federally Inspected steer-heifer dressed carcass weight, and

408 = estimated weaned beef calf weight, and

.745 = proportion of beef calves slaughtered as fed and non-fed steer and heifer beef as shown in Table 1.

Coefficients for converting live weaned dairy calves to veal carcass meat and steer-heifer meat were derived as follows. The average dressed veal carcass weight for 1976-77 was 147.93 pounds as reported by the U.S. Department of Agriculture in Livestock and Meat Situation, February, 1978 Carcass weights for fed and non-fed dairy steers and heifers, although often heavier, were assumed to be the same as beef steers and heifers at 635.63 pounds since this statistic includes total Federal Inspected steer and heifer slaughter. These coefficients were developed as follows:

$$\text{Dairy calf to veal carcass} = \frac{(147.93)}{85} \times (.3825) = .665685$$

$$\text{Dairy calf to steer-heifer carcass} = \frac{(635.63)}{85} \times (.2250) = 1.68255$$

where:

147.93 = average dressed Federally Inspected Veal Carcass weights for 1976-77,

85 = estimated average weaning weight of a dairy calf

.3825 = proportion of dairy calves slaughtered as veal, Table 2.

.2250 = proportion of dairy calves slaughtered as fed and non-fed steers and heifers, and the other variables have been previously identified, Table 2.

Table 1. Estimated Disposition per 100 Beef Calves, by Sex, 1976-91.

Item	Sex		Total
	Bulls(Steers)	Heifers	
	Head		
Sex at birth	50.0	50.0	100.0
Disposition:			
Death loss	2.0	2.0	4.0
Replacements	1.5	20.0[a]	21.5
Non-fed slaughter	3.0	4.5	7.5
Fed slaughter	43.5	23.5	67.0

[a] Total heifers designated as replacement. Actual replacements are approximately 17 percent.

Table 2. Estimated Disposition per 100 Dairy Calves, by Sex, 1976-91.

Item	Sex		Total
	Bulls(Steers)	Heifers	
	Head		
Sex at birth	50.0	50.0	100.0
Disposition:			
Death loss	2.0	2.0	4.0
Replacements	.25	33.0[a]	33.25
Veal slaughter	31.75	6.5	38.25
Non-fed slaughter	5.0	6.0	11.0
Fed slaughter	10.0	1.5	11.50

[a] Total heifers designated as replacements. Actual replacements are approximately 28 percent.

ANNEX 5

PROCEDURES FOR ESTIMATING COEFFICIENTS TO DETERMINE PHYSICAL LOSSES PER INFECTED DAIRY COW

Losses due to brucellosis in the dairy industry are manifested primarily in decreased milk production, premature culling resulting in increased replacement costs to affected producers, and dead calves as a result of abortions. Losses in the dairy industry, similar to the beef industry, vary depending upon management and culling practices, levels of vaccination and whether infected herds are identified as shown in Tables 10, 11 and 12. The basic input data for determining these losses are shown in Table 9. In addition, it was assumed that the dairy industry culling rate was 75 percent for aborters and 28.1 percent for non-aborters.[1/] The percentage of infected cows to be included in each selected loss category, by year of infection, were computed as follows for Region 1 in unvaccinated and undetected herds:

Culled

Year 1 = (.60) (.75) + (.281) (.40) = .5624

where

60.0 = percent aborting in the first year of infection,

75.0 = percent of aborters culled,

28.1 = percent of non-aborting cows culled,

40.0 = percent of non-aborting cows in the first year of infection.

Year 2

Dairy producers similar to beef producers, do not cull all infected cows in unidentified herds. Consequently non-culled infected cows were carried over into both the year 2 and year 3 infection category. This was accomplished as follows for year 2:

Carryovers from Year 1 = 1.5624 = .4376

Newly infected in Year 2 = 2[2/] - .4376 = 1.5624

[1/] The standard culling rate of .281 within the dairy industry was derived from Costs of Producing Milk In The United States, 1975 and 1976, Senate Committee on Agriculture and Forestry, U. S. Congress, Washington, D. C., 1977.

[2/] See footnote 1, page 2, Annex 4.

The culling rates within herds in the second year of infection are:

Year 1 carryovers = [.4376] [(.05) (.75) + (.95) (.281)] = .1332

Newly infected cows = [1.5624] [(.60) (.75) + (.40) (.281)] = .8787

The culling rate is $\frac{.332 + .8787}{2}$ = .5060.

where

5.0 = percent of infected cows aborting in the second year of infection,

95.0 = percent of non-aborting cows in the second year of infection and the other variables have been previously identified.

Year 3

Carryovers from Year 1 = .4376 - .1332 = .3044

Carryovers from Year 2 = 1.5624 - .8787 = .6837

Newly infected cows = 2 - .3044 - .6837 = 1.0119

The culling rates within herds in the third year of infection are:

Carryovers from Year 1 = [.3044] [(.001) (.75) + (.999) (.281)] = .0857

Carryovers from Year 2 = [.6837] [(.05) (.75) + (.95) (.281)] = .2082

Newly infected cows = [1.0119] [(.60) (.75) + (.40) (.281)] = .5691

The culling rate is $\frac{.0857 + .2082 + .5691}{2}$ = .4315

where

0.1 = percent aborting in the third year of infection, and

99.9 = percent of non-aborting cows in the third year of infection and the other variables have been previously identified.

Have Dead Calves

Year 1 = (.60) + (.40) (.30) (.10) = .6120

where

60.0 = percent of infected cows aborting in the first year of infection,

40.0 = percent of non-aborting cows in the first year of infection,

30.0 = percent of non-aborting cows with weak calves in the first year of infection,

10.0 = death loss as a result of weak calves.

Year 2

Year 1 carryovers = [.4376] [(.05) + (.95) (.06) (.10)] = .0244

Newly infected cows = [1.5624] [(.60) + (.40) (.30) (.10)] = .9562

Cows with dead calves = $\frac{.0244 + .9562}{2}$ = .4903

where

5.0 = percent of infected cows aborting in the second year of infection,

95.0 = percent of non-aborters in the second year of infection,

6.0 = percent of non-aborters with weak calves in the second year of infection and the other variables have been previously identified.

Year 3

Year 1 carryovers = [.3044] [(.001 = (.999) (.03) (.10)] = .0012

Year 2 carryovers = [.6837] [(.05) + (.95) (.06) (.10)] = .0381

Newly infected cows = [1.0119] [(.60) + (.40) (.30) (.10)] = .6193

Cows with dead calves = $\frac{.0012 + .0381 + .6193}{2}$ = .3293

where

0.1 = percent of infected cows aborting in the third year of infection,

99.9 = percent of non-aborters in thethird year of infection,

3.0 = percent of non-aborters with weak calves in the third year of infection and the other variables have been pre-

previously identified.

Milk losses per infected dairy cows were computed similarly to the procedures outlined above with the followinf exceptions and/or assumptions. The following assumptions were made relative to milk losses for unvaccinated and undetected herds:

(1) aborters in the year in which abortion occurs and non-aborters in any year = 8.0 percent of annual production.

(2) the next year following abortion = 20.0 percent of annual production and all subsequent years following abortion = 8.0 percent.

(3) Dairy producers often do not find replacements immediately of equal milking ability as cows called for brucellosis. This "empty stall loss" due to the absence of an adequate replacement in the milking line was assumed to be one month in a ten month lactation period or 10.0 percent of the annual production.

The procedures for determining direct milk losses due to brucellosis and an "empty stall loss" per infected dairy cow in unvaccinated, detected herd, by year of infection was as follows:

Milk Loss

Year 1 = (.60) (.08) + (.40) (.08) = .08

where

60.0 = percent of infected cows aborting in the first year of infection,

8.0 = percent of annual milk loss in aborting cows during the year of abortion,

40.0 = percent non-aborters in the first year of infection,

8.0 = percent of annual milk loss in non-aborting cows.

Year 2

Since it was assumed that 75 percent of the aborting dairy cows are culled in undetected herds, 25 percent of these aborters move into the second year of infection as "prior year aborters" and undergo a 20.0 percent reduction in milk production due to difficulties in starting the next lactation as well as damage to the mammary tissue. This necessitated the subdivision of non-culled carryovers into "prior year aborters" and "non-aborters". This involved the following calculations:

Carryovers from Year 1 = 1 - .5624 = .4376.

(1) Prior year aborters = (.60) (.25) = .1500.

(2) Year 1 non-aborters not culled = (.40) (.719) = .2876.

where

60.0 = percent of infected cows aborting in the first year of infection,

25.0 = percent of aborting cows not culled,

40.0 = percent of non aborters in the first year of infection,

71.9 = percent of non aborting cows not culled.

Milk losses within herds in the second year of infection are:

Year 1 carryovers = (.15) (.20) + (.2876) (.08) = .0530

Newly infected cows = [1.5624] [(.60) (.08) + (.40) (.08)] = .1250

The milk loss is $\frac{.0530 + .1250}{2} = .0890$.

Year 3

Carryovers from Year 1 = .4376 - .1332 = .3044

(1) Prior year aborters = (.4376) (.05) (.25) = .0055

(2) Year 1 non-aborting carryovers not culled = (.4376) (.95) (719) = .2989

where

5.0 = percent aborting in the second year of infection,

95.0 = percent non-aborters in the second year of infection and the other variables have been previously identified.

Carryovers from Year 2 = 1.5624 - .8787 = .6837

(1) Prior year aborters = 1.5624- .8787 = -6837

(2) Year 2 non-aborting carryovers not culled = (1.5624) (.40) (.719) = .4493

Milk losses within herds in the third year of infection are:

Year 1 carryovers = (.0055) (.20) + (.2989) (.08) = .0250

Year 2 carryovers = (.2344) (.20) + (.4493) (.08) = .0828

Newly infected cows = [1.0119] [(.60) (.08) + (.40) (.08)] = .0810

The milk loss is $\frac{.0250 + .0828 + .0810}{2}$ = .0944.

In addition to the direct milk loss coefficients derived above, direct milk losses due to the absence of replacements in the milking line or "empty stall loss" was computed per infected cow in undetected herds as follows:

Year 1 = (.60) (.75) (.10) (.3333) = .0150

where

60.0 = percent of infected cows aborting in the first year of infection,

75.0 = percent of aborting cows culled,

10.0 = percent milk loss due to absence of replacements in the milking line, and

33.33 = percent of aborting cows culled prior to end of lactation in unidentified herds.

Year 2

Year 1 aborters not culled = (.15) (.75) (.10) (.3333) = .0038

Newly infected cows = [1.5624] [(.60) (.75) (.10) (.3333) = .0234

Milk loss due to empty stalls = $\frac{.0038 + .0234}{2}$ = .0136

where

15.0 = precent of aborters carried over from year 1 and the other variables have been previously identified.

Year 3

Year 1 aborters not culled = (.0055) (.75) (.10) (.3333) = .0001

Year 2 aborters not culled = (.2344) (.75) (.10) (.333) = .0059

Newly infected cows = (1.0119) (.60) (.75) (.10) (.333) = .0152

Milk loss due to empty stalls = $\frac{.0001 + .0059 + .0152}{2}$ = .0106

In addition to the direct milk losses attributable to (1) losses due to brucellosis and (2) empty stall losses, it was also assumed that owners of infected herds often cannot find replacements equal to the milking ability of dairy cows which had to be culled due to brucellosis. Such losses were termed "genetic losses" and were assumed to be equal to 8 percent of the annual production for cows culled as a result of brucellosis as described in Annex 6.

The total milk losses per infected dairy cow in undetected and unvaccinated dairy herds, by year of infection, is as follows:

Milk Loss	Year 1	Year 2	Year 3
	Percent		
Direct	8.00	8.90	9.44
Empty stall	1.50	1.36	1.06
Genetic	8.00	8.00	8.00
Total	17.50	18.26	18.50

The direct milk losses for unvaccinated and detected dairy cows were assumed equal to one-half of that of the undetected herds. However, since the culling rate for detected infected cows is 100 percent and since infected cows can be detected anytime during lactation or otherwise, it was assumed that empty stall losses for detected infected dairy cows was equal to 10 percent per detected dariy cow. Genetic losses per detected dariy cow, as in undetected herds, was assumed to be 8 percent per infected cow.

In addition to the above data, other basic data used to develop economic losses in the dairy industry, by region, are shown below.

Region	Milk production per cow 3/	Blend milk price 4/	Slaughter cow price 4/	Slaughter veal price 4/	Cull cow weights 4/
	Pounds	\$/Cwt.	\$/Cwt.	\$/Cwt.	Pounds
1	10,699	9.05	23.78	34.25	1,200
2	10,291	9.49	22.88	35.55	1,200
3	8,508	9.16	22.25	31.28	1.185
4	10,000	11.57	22.25	27.10	1,100
5	9,025	10.04	21.35	27.06	1,120
6	9,479	8.53	23.12	32.22	1,200
7	11,789	9.19	23.41	30.36	1,200
8	13,935	9.12	24.04	30.10	1,200

3/ Dairy Situation, DS-369, W.S. Department of Agriculture, March, 1968.

4/ Costs of Producing Milk In The United States, 1975 and 1976, Senate Committee on Agriculture and Forestry, U.S. Congress, Wash., D.C. '77.

The replacement losses suffered by dairy operators as a result of forced or premature culling of infected dairy cows were computed on a regional basis as follows. The average replacement cost for a dairy cow during 1975-76 was $543 according to a study, Costs of Producing Milk In The United States (footnote 4). This average replacement cost was adjusted by a regional production index per dairy cow for 1975-76. The regional production index per dairy cow was obtained by dividing the regional milk production per cow as shown above by 10,566, the average U.S. milk production per dairy cow during 1975-76. The per cow replacement losses were then calculated for each region. Per cow replacement losses in region 1, for example, are

$$\left(\frac{10{,}699}{10{,}566}\right) (543) - (1{,}200)\ (.96)\ (.2378) = \$275{,}89 \text{ where } 1{,}200$$

represents the slaughter weight per cow, .2378 is the average slaughter price per cow and .96 represents a 4 percent shrink.

Annex 6

Estimating Decreased Milk Production Potential as a Result of Increased Involuntary Culling of Cows Due to Brucella Abortus Infection.[1/]

Culling cows because they are serologically positive for Brucella abortus adds to involuntary culling for such reasons as age and disorders of reproductive system, mammary gland and feet. This forces the dairy producer to "dip/over" into his genetic pool for selection of cows to keep in his herd. He looses some degree of selection intensity for milk production. The magnitude of this selection intensity loss at different involuntary culling rates and its estimated effect on milk production is described in the following discussion by Professor Conlin.

"Losses due to involuntary Culling of aborted cows can be estimated using a standard statistical procedures.

Standard Deviation Among Cows Wighin Herds

Increased Rate of Involuntary Culling	Selection Intensity Loss	ME S.E. ± 2400	Act. Prod. S.D ± 3000	Genetic S.D ± 1000
10%	.2	480	600	200
15	.27	648	810	270
25	.42	1008	1260	420

Actual production is the effect on pounds of milk per cow because of increased forced·culling and reduction in voluntary culling for production. This will occur in lactation following abortion. Therefore a 10-25% abortion rate and those cows culled will result in 600 to 1260 pounds of milk less per cow sold because these cows were culled.

In addition, future culling opportunities will be severely affected because of fewer replacements available to enter the herd. This will affect future culling two ways:

(1) Poorer heifer replacements available
(2) Fewer heifer replacements available

Another consideration is that the number of replacement heifers born during the abortion period will be reduced which will reduce bred heifer

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[1] This Annex statement was prepared by Dr. E. Hunt McCauley. It is based on consultation with Professor Joe Conlin, Dairy Scientist at the University of Minnesota. Professor Conlin provided the statistical approach to making this loss estimate. The background for this and an excellent discussion of the important topic of genetic progress is presented in an article by Professor Conlin entitled "Management Factors That Influence Genetic Progress" on pages 121-130 of the Proceedings of the National Workshop on Genetic Improvement of Dairy Cattle held in St. Louis, Missouri, April 6 and 7, 1976.

replacements available from within the herd two years later. Therefore voluntary culling for production will be reduced unless more replacements are purchased. The effect will be essentially the same as it was the year after the abortion storm occurred; i.e.

Abortion Rate

10%	600 lbs. milk
15%	810 lbs. milk
25%	1260 lbs. milk

The 600 to 1260 pounds of milk per cow loss will repeat itself in the second year following the increased culling because of fewer herd replacements.

In later years, the herd replacements available will be poorer genetically by 200 to 270 pounds of milk because of the good cows that did not have calves that could have been used as replacements. This will decrease the herd average of all cows in the herd approximately by 50 to 80 pounds of milk per cow."

In suggesting an estimate for this loss, I have elected to use 810 pounds per cow involuntarily culled as occurring in the year following the culling. As one can see from Professor Colin's discussion, this figure is conservative on two counts: 1) it is for a 15% increased involuntary culling rate when actually this rate could be much higher (or lower), 2) it does not reflect the cascading effect of losses in future years due to decreased number of heifer genetic potential from abortions and to not having calves from the cows involuntarily culled. In disregarding point 2, I am arguing, for simplicity, that because of the time distance away from the initial cause (culling with or without abortion) that some factors may come into play which would offset these later losses.

Annex 7

A DYNAMIC PRICE RESPONSE SIMULATION MODEL OF THE U.S. DAIRY INDUSTRY[1]

The U.S. Dairy Industry

Presently there are two grades of milk produced in the United States, Grade A and Grade B. Grade A milk is produced under strict sanitary regulations which permit this milk to be packaged for fluid consumption. Grade B, or manufacturing grade milk, is not produced under such stringent sanitary regulations. Nearly all of it is manufactured into products such as butter, cheese, or powdered milk. In 1977, over eighty percent of the milk produced in the United States was Grade A, while Grade B constitutes the remainder (USDA).

Approximately eighty percent of the Grade A production is subject to minimum price regulation at the producer level through the federal milk marketing orders. A majority of the remaining Grade A milk is subject to minimum price regulation by various state milk marketing orders. Grade B production does not come under the regulation of federal or state milk marketing orders. It relies on the price support program for a floor price and is otherwise priced in the open market.

Grade A milk used for fluid consumption is known as Class I milk. Class II milk is Grade A milk used in the production of "soft" dairy products such as ice cream, cottage cheese, yogurt and sour cream. The remaining Grade A milk, Class III, is used in manufacturing products along with Grade B. Class III and Grade B milk, therefore, compete in the same end-use market. This procedure of classifying milk according to use and pricing each class differently is referred to as the classified pricing system.

The mechanism by which minimum Class I price is currently set in the federal milk marketing orders is a fixed differential above the competitive price for milk used in manufacturing. The competitive pay price used is known as the Minnesota-Wisconsin (M-W) price series. The M-W price is determined montly via a USDA sampling of the prices paid for milk by dairy product manufacturers in Minnesota and Wisconsin. Over half of the U.S. Grade B milk production is concentrated in these two states and historically this area has had a comparative advantage in producing milk. The M-W is considered to be the best indicator of overall industry supply-demand conditions and thus a competitive price.

The Class I price at the base pricing point, Eau Claire, Wisconsin, is a fixed differential above the observed M-W price two-months previous. The level of Class I prices in the U.S. follows concentric circles from this base pricing point, determined by the cost of transporting one hundred pounds of fluid milk in hundred mile increments. Thus, as

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1. Prepared by Dr. E. A. Smith, Department of Agricultural Economics, Texas A & M University; July, 1978.

one moves further away from Eau Claire, the minimum Class I price increases in accordance to transport costs.

Though fluid markets are regional in nature, the market for manufactured dairy products is national. The ratio of cost of transportation to the value of manufactured dairy products is relatively low, especially in comparison to fluid milk. Because of this low cost of transport of product value, the value of milk destined for manufacturing purposes will be the same, or nearly the same, throughout its national market. Thus, the value of Grade A milk used in manufacturing can be no more than the price of the unregulated Grade B market.

The price the producer of Grade A milk receives for his milk is the blend price or average price. An individual Grade A producer is indifferent to whether he sells his milk as Class I or for manufacturing. Because all receipts for an order are pooled, each producer receives the average order price, or blend price.

Review of Literature: Studies of the Supply and Demand for Milk and Dairy Products.

Supply

There have been numerous analyses of supply response of aggregate U.S. and regional-state milk production. These analyses have been of a structural nature utilizing single equation models, either measuring short-run effects or the partial adjustment hypothesis; simultaneous equations for the estimation of the number of cows and yield per cow; or recursive models of milk production.

Early works by Rojko, Halvarson (1955), and Cochrane measured the short-run price elasticity of supply to be less than 0.2. Later, Halvarson (1958), Wipf and Houck, and Hammond determined the coefficient of adjustment, (Nerlove), to be between 0.4 and 0.6. Wilson and Thompson, and Prato estimated cow numbers and production per cow as part of simultaneous equation models of the U.S. dairy industry.

Jackson employed a polynominal lag structure of price to estimate the number of cows and yield per cow for each of ten regions he chose for the United States. Hammond estimated the milk supply relationship for each of nine regions he chose to represent the United States. The supply elasticities with respect to price were found to be inelastic in both studies though these elasticities differed among regions.

The results of all of these studies concur that in the short-run the milk supply is highly inelastic and somewhat more elastic in the longer run. The price milk producers receive for their milk and production costs, especially feed, were consistently identified as factors affecting the supply of milk.

Demand

Like most food items the demand for dairy products is price and

income inelastic. The price elasticity of fluid products has been estimated at between -0.2 and -0.35 and the income elasticity from 0.03 to 0.54. The demand for manufactured dairy products has been found in most cases to be more price and income elastic. The major means of estimating these elasticities have been time series analysis, all food elasticities, and cross sectional studies.

Table 1 summarizes the more comprehensive studies of the demand for dairy products. Though not included in Table 1, notable variables used for substitute products have been the price of beverages for fluid demand and prices of meats for manufactured products, especially cheese.

Industry Models

There have been few studies which have formulated a complete model of the dairy industry and estimated the parameters. The before-mentioned simultaneous equations approach by Wilson and Thompson, and Prato are notable exceptions. Hallberg and Fallert developed regional models of the industry, but restricted coefficients in their estimation process so as to have desirable parameter signs.

The models developed by Kwoka, Oppalito and Masson, and Buxton to measure welfare loss due to price regulation were not empirically estimated. *A priori* information on price and income elasticities were used in these studies.

The Model

The model used in this analysis of the dairy industry assumes all milk to be one single grade, Grade A. The basis for the use of such a model is the difficulty in ferreting out from aggregate data federal order Grade A milk, Grade B milk and milk controlled by the various State milk marketing orders. Also, it is anticipated that in the future nearly all milk will be of a single grade.

Since Class I prices in all the Federal orders are linked together in a systematic manner, the demand arrives for Class I milk in each market may be summed horizontally as if all the Class I milk were in a single federal order. Likewise, the demand curve for manufacturing milk, Grade A or B, may be depicted in this single market due to its national scope. The supply of milk is a function of the blend price and cost of producing milk.

In functional form, this single market may be modeled as,

$$(1)\quad O_f^\tau = \phi(P_f^\tau,\ Ync^\tau,\ QT_j) \qquad \text{(fluid demand)}$$

$$(2)\quad P_m^\tau = \begin{cases} \theta(Q_m^\tau,\ Ync^\tau,\ QT_j) & \text{if } \theta(Q_m^\tau,\ Ync^\tau) > P_s^\tau \\ P_s^\tau & \text{if } \theta(Q_m^\tau,\ Ync^\tau) \le P_s^\tau \end{cases} \qquad \text{(manufacturing demand)}$$

Table 1 Price and Incomes Elasticities for Dairy Products

Author	Elasticity Price	Elasticity Income	Type of Study
	A. Fluid Milk		
Rojko	-.32	.27	Time Series 1947-54
Hu	-.31	.03	Time Series 1947-63
Brandow	-.29	.16	Allfood elast. 1955-57
George & King	-.34	.20	Allfood elast. 1946-66
Burk	-.35	.35	Time Series 1947-67
McDonald	-.13		Time Series 1962-69
Boehm & Babb	-.14	.05	Cross Section 1972-74
	B. Frozen Dairy Products		
Brandow	-.55	.35	Allfood elast. 1955-57
George & King	-.52	.33	Allfood elast. 1946-66
Burk	-.33	.25	Time Series 1947-67
Boehm & Babb	-.42	.07	Cross Section 1972-74
	C. Cheese		
Rojko	-.75	.63	Time Series 1947-54
Hu	-.11	.30	Time Series 1947-63
Brandow	-.70	.45	Allfood elast. 1955-57
George & King	-.52	.33	Allfood elast. 1946-66
Burk	-.19	.29	Time Series 1947-67
Boehm & Babb	-.85	.23	Cross Section 1972-74
	D. Butter		
Rojko	-1.37	.36	Time Series 1947-54
Hu	-1.14	.65	Time Series 1947-63
Brandow	-.85	.33	Allfood elast. 1955-57
George & King	-.65	.31	Allfood elast. 1946-66
Burk	-.33	.38	Time Series 1947-67
Quackenbusch & Shaffer	-.46	.60	Cross Section 1948
Boehm & Babb	-.73	.17	Cross Section 1972-74

(3) $Q_s^{\tau} = \Psi(P_{\beta}^{\tau-4}, \text{Cost}, {}^{\tau}QT_j)$ (milk supply)

where the variables are defined as,

Q_f^{τ} = Federal order producer milk deliveries used in Class I during time period τ, million pounds (<u>Federal Milk Order Market Statistics</u>).

Q_s^{τ} = Total U.S. milk production during time period τ, million pounds, (<u>Dairy Statistics</u>).

Q_m^{τ} = Quantity of milk used in production of manufactured products during time period τ, million pounds, where $Q_m^{\tau} = Q_s^{\tau} - Q_f^{\tau}$.

P_f^{τ} = All market Federal order minimum Class I price during time period τ, dollars per hundred weight, (<u>Federal Milk Order Market Statistics</u>).

P_m^{τ} = Average price of manufacturing grade milk during time period τ, dollars per hundred weight, (<u>Dairy Situation</u>).

P_s^{τ} = Support price in time period τ, dollars per hundred weight.

P_{β}^{τ} = Blend price during time period τ-4, dollars per hundred weight where $P_{\beta}^{\tau-4} = (P_f^{\tau-4}\ Q_f^{-4} + P_m^{\tau-4}\ Q_m^{\tau-4}) \div (Q_s^{\tau-4})$

Ync^{τ} = Nominal per capita disposable income during time period τ, dollars, (<u>Business Conditions</u>).

$Cost^{\tau}$ = Composite input factor price during time period τ, (<u>Agricultural Prices</u> and <u>Farm Labor</u>).1/

QT_j = Binary variable, (0-1) to take into account the effect of quarter, j = (2, 3, 4).

The minimum Class I price is set in a market administratively. Given a level of the Class I price and income, a unique level of milk is demanded for fluid use. The residual milk then goes to manufacturing purposes.

This milk determines the level of manufacturing price. If the open market price is less than or equal to the support price, the effective market price would then become the support price. The support price is maintained by government purchases of manufactured dairy products.

1/ This composite input price is made up of 37% price of corn, 21% price of 16% protein dairy concentrate, 16% hourly wage of farm labor and 26% prices paid by farmers. See Smith for details.

Because of imperfections in the government's ability to purchase manufactured dairy products which will make the support price the absolute floor, at times the manufacturing price dips below the support price. In modeling the dairy industry, one can relax the condition of a perfectly elastic demand for manufacturing milk at the price support level.

The above model was estimated via three stage least squares, (3SLS) on quarterly observations for 1970-1976. The use of simultaneous equation techniques is desirable because of the necessity of using the fluid demand and total supply relationships in determining the values of the quantity of milk used in manufacturing (Kmenta). Three stage least squares has all of the desirable asymptotic properties of an estimator.

The resulting estimated model is:1/

$$Q_s^\tau = \underset{}{10465.82} - \underset{(37.5)}{221.95} P_s^\tau + \underset{(.072)}{0.4402}\, Ync^\tau$$

$$\underset{(74.5)}{-645.4} QT_2 - \underset{(75.7)}{732.7} QT_3 - \underset{(75.1)}{98.4} QT_4$$

$$P_m^\tau = 14.80 - \underset{(.0004)}{0.000916}\, Q_m^\tau + \underset{(.0003)}{0.00295}\, Ync^\tau$$

$$+ \underset{(1.3)}{1.5} QT_2 - \underset{(.53)}{}QT_3 - \underset{(1.2)}{1.8} QT_4$$

$$Q_s^\tau = 28292.8 + \underset{(217.2)}{865.24}\, P_\beta^{\tau-4} - \underset{(263.4)}{935.46}\, Cost^\tau$$

$$+ \underset{(439.9)}{2835.6}\, QT_2 - \underset{(438.4)}{590.7}\, QT_3 - \underset{(445.1)}{2907.3}\, QT_4$$

All of the coefficients in the estimated model are significant at the 5% level and have the expected signs. From the estimated model, using Walker's adjustment procedure the annual average model becomes,

$$Q_s^\tau = 10096.69 - 221.95\, P_s^\tau + .4402\, Ync^\tau$$

$$P_m^\tau = 14.48 - .000916\, Q_m^\tau + .00295\, Ync^\tau$$

$$Q_s^\tau = 28127.27 + 865.24\, P_\beta^{\tau-4} - 935.464\, Cost^\tau$$

1/ The values in parenthesis under the estimated coefficients are their respective standard error of estimates.

The annual average model is desirable because of its use in a simulation program which measures the price response due to milk loss because of brucellosis.

Simulation Model

The program used to simulate the dairy industry may be found in Addendum I. The base period used is 1975 with the blend price, income and cost values reflecting this.

The program does the following. Quantity produced is a function of the previous year's blend price and current cost conditions. Once this production has been estimated, net milk loss for that year due to brucellosis is deducted.[1]

Because there is a direct tie between the prices of fluid milk and manufacturing milk (Class I differential), market clearing conditions may be solved in regard to the unknown variable, price of manufacturing milk. There is a historic differential of $2.15 between Class I and manufacturing prices which is used to obtain the fluid price. Quantity demanded of fluid and manufacturing milk are determined and then that period's blend price.

There are eight (8) regions used in this study because of regionality of the infection of brucellosis. Likewise, a given year's blend price is regionalized based on historic price differentials within the Federal order system. These regional prices are used in estimation of the economic impact of brucellosis on producer's income.

The income and cost used for the following year are adjusted by 1.05 to approximate the expected inflation rate. The blend price in the present period is then used to estimate production for the next period, etc. The simulation may be carried for N number of lead periods.

In order to validate the simulation model an assumption of no changes in the exogenous variables Ync and Cost, are allowed over time. As expected, a stable equilibrium is obtained after seven years, Table 2. The regional price patterns for this example are shown in Table 3.

Using an assumption of an inflation rate of 5% per year and the present brucellosis program in effect, the prices generated are shown in Table 4, for the U.S. and Table 5 for each of the eight regions. Table 6 shows the results of an assumption of 5% inflation and a loss of milk due to brucellosis of 10% of total production the first year with an increasing loss of 2.5% each succeeding year.

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[1]Net loss is defined as the differences between losses under the current program and the losses of the proposed programs divided by four (4) to adjust to the annual overall model.

Table 2. Simulated U.S. Average Fluid, Manufacturing and Blend Prices: No Changes in Exogenous Variables and Present Brucellosis Program.

YEAR	MAN PRICE	FID PRICE	BLEND PRICE
1	8.99	11.14	9.74
2	8.25	10.40	8.98
3	8.65	10.80	9.38
4	8.44	10.59	9.17
5	8.55	10.70	9.28
6	8.49	10.64	9.22
7	8.52	10.67	9.25
8	8.50	10.65	9.24
9	8.51	10.66	9.24
10	8.51	10.66	9.24
11	8.51	10.66	9.24
12	8.51	10.66	9.24
13	8.51	10.66	9.24
14	8.51	10.66	9.24
15	8.51	10.66	9.24
16	8.51	10.66	9.24
17	8.51	10.66	9.24
18	8.51	10.66	9.24
19	8.51	10.66	9.24
20	8.51	10.66	9.24

Table 3. Simulated Regional Fluid, Manufacturing and Blend Prices: No Changes in Exogenous Variables and Present Brucellosis Program.

YEAR	REG 1	REG 2	REG 3	REG 4	REG 5	REG 6	REG 7	REG 8
1	8.64	9.57	8.64	9.74	9.14	8.49	8.79	8.94
2	7.88	8.81	7.88	8.98	8.38	7.73	8.03	8.18
3	8.28	9.21	8.28	9.38	8.78	8.13	8.43	8.58
4	8.07	9.00	8.07	9.17	8.57	7.92	8.22	8.37
5	8.18	9.11	8.18	9.28	8.68	8.03	8.33	8.48
6	8.12	9.05	8.12	9.22	8.62	7.97	8.27	8.42
7	8.15	9.08	8.15	9.25	8.65	8.00	8.30	8.45
8	8.14	9.07	8.14	9.24	8.64	7.99	8.29	8.44
9	8.14	9.07	8.14	9.24	8.64	7.99	8.29	8.44
10	8.14	9.07	8.14	9.24	8.64	7.99	8.29	8.44
11	8.14	9.07	8.14	9.24	8.64	7.99	8.29	8.44
12	8.14	9.07	8.14	9.24	8.64	7.99	8.29	8.44
13	8.14	9.07	8.14	9.24	8.64	7.99	8.29	8.44
14	8.14	9.07	8.14	9.24	8.64	7.99	8.29	8.44
15	8.14	9.07	8.14	9.24	8.64	7.99	8.29	8.44
16	8.14	9.07	8.14	9.24	8.64	7.99	8.29	8.44
17	8.14	9.07	8.14	9.24	8.64	7.99	8.29	8.44
18	8.14	9.07	8.14	9.24	8.64	7.99	8.29	8.44
19	8.14	9.07	8.14	9.24	8.64	7.99	8.29	8.44
20	8.14	9.07	8.14	9.24	8.64	7.99	8.29	8.44

Table 4. Simulated U. S. Average Fluid, Manufacturing and Blend Prices: Five Percent Inflation Rate and Present Brucellosis Program.

YEAR	MAN PRICE	FID PRICE	BLEND PRICE
1	8.99	11.14	9.74
2	9.03	11.18	9.76
3	9.84	11.99	10.57
4	10.28	12.43	11.00
5	10.95	13.10	11.68
6	11.55	13.70	12.27
7	12.24	14.39	12.96
8	12.93	15.08	13.64
9	13.67	15.82	14.38
10	14.44	16.59	15.15
11	15.25	17.40	15.95
12	16.10	18.25	16.80
13	16.99	19.14	17.69
14	17.93	20.08	18.63
15	18.92	21.07	19.61
16	19.95	22.10	20.64
17	21.04	23.19	21.72
18	22.18	24.33	22.85
19	23.37	25.52	24.05
20	24.63	26.78	25.30

Table 5. Simulated Regional Fluid, Manufacturing and Blend Prices: Five Percent Inflation Rate and Present Brucellosis Program.

YEAR	REG 1	REG 2	REG 3	REG 4	REG 5	REG 6	REG 7	REG 8
1	8.64	9.57	8.64	9.74	9.14	8.49	8.79	8.94
2	8.66	9.59	8.66	9.76	9.16	8.51	8.81	8.96
3	9.47	10.40	9.47	10.57	9.97	9.32	9.62	9.77
4	9.90	10.83	9.90	11.00	10.40	9.75	10.05	10.20
5	10.58	11.51	10.58	11.68	11.08	10.43	10.73	10.88
6	11.17	12.10	11.17	12.27	11.67	11.02	11.32	11.47
7	11.86	12.79	11.86	12.96	12.36	11.71	12.01	12.16
8	12.54	13.47	12.54	13.64	13.04	12.39	12.69	12.84
9	13.28	14.21	13.28	14.38	13.78	13.13	13.43	13.58
10	14.05	14.98	14.05	15.15	14.55	13.90	14.20	14.35
11	14.85	15.78	14.85	15.95	15.35	14.70	15.00	15.15
12	15.70	16.63	15.70	16.80	16.20	15.55	15.85	16.00
13	16.59	17.52	16.59	17.69	17.09	16.44	16.74	16.89
14	17.53	18.46	17.53	18.63	18.03	17.38	17.68	17.83
15	18.51	19.44	18.51	19.61	19.01	18.36	18.66	18.81
16	19.54	20.47	19.54	20.64	20.04	19.39	19.69	19.84
17	20.62	21.55	20.62	21.72	21.12	20.47	20.77	20.92
18	21.75	22.68	21.75	22.85	22.25	21.60	21.90	22.05
19	22.95	23.88	22.95	24.05	23.45	22.80	23.10	23.25
20	24.20	25.13	24.20	25.30	24.70	24.05	24.35	24.50

Table 6. Simulated U.S. Average Fluid, Manufacturing, and Blend Prices: Five Percent Inflation Rate and Milk Loss of 10% Increasing by 2.5% yearly.

YEAR	MAN PRICE	FID PRICE	BLEND PRICE
1	10.72	12.87	11.52
2	10.46	12.61	11.23
3	11.84	13.99	12.63
4	12.53	14.68	13.32
5	13.58	15.73	14.38
6	14.52	16.67	15.33
7	15.57	17.72	16.39
8	16.64	18.79	17.47
9	17.77	19.92	18.61
10	18.94	21.09	19.79
11	20.16	22.31	21.02
12	21.44	23.59	22.31
13	22.77	24.92	23.66
14	24.17	26.32	25.06
15	25.62	27.77	26.54
16	27.15	29.30	28.08
17	28.74	30.89	29.69
18	30.41	32.56	31.37
19	32.15	34.30	33.14
20	33.98	36.13	34.99

ADDENDUM

U.S. Dairy Simulation Program

```
//ART JOB (L700,5D,S02,5,AS),'MILK'
/*JOBPARM R=192,HOLDOUT
/*WATFIV
C
C
C
C      N IS THE NUMBER OF YEARS OF SIMULATION FROM THE BASE
C      PB IS THE U.S. BLEND PRICE
C      COST IS THE COST COMPONENT USED IN ESTIMATING TOTAL PRODUCTION
C      YNC IS THE PERCAPITA DISP. INCOME USE IN THE DEMAND EQUATIONS
C      QS IS TOTAL QUANTITY PRODUCED OR QS=F(PB,COST),PB LAGGED 1
C      LOSS IS THE QUANTITY OF MILK LOST DUE TO INFECTION
C      QSS IS THE NET AMOUNT OF MILK ON THE MARKET
C      PM IS THE MANUFACTURING PRICE OF MILK OR PM=F(QM,YNC)
C      QF IS THE QUANTITY OF FLUID MILK DEMANDED OR QF=F(PF,YNC)
C      QM IS THE QUANTITY OF MANUFACTURED MILK DEMANDED OR QM=QS-QF
C      COST(I+1) IS THE COST INFLATED
C      YNC(I+1) IS THE INCOME INFLATED
C      REGION(J,I) IS THE REGIONAL PRICES WHERE J=1-8 AND J=1-N
C
C
C
       DIMENSION QS(50),QSS(50),PMM(50),PM(50),PF(50),COST(50),
      2YNC(50),PB(50),QF(50),QM(50),REGION(8,50)
       REAL LOSS(50)
       N=20
       PB(1)=8.30
       COST(1)=5.70
       YNC(1)=5504
       WRITE(6,100)
C      PUT IN THE NET LOSSES
C
       DO 9 I=1,N
     9 LOSS(I)=0
C
       DO 10 I=1,N
       QS(I)=28127.27+(865.24*PB(I))-(935.464*COST(I))
       QSS(I)=QS(I)-LOSS(I)
       PMM(I)=19.38-(.00076*QSS(I))+(.00274*YNC(I))
       PM(I)=-.7177+(.7839*PMM(I))
       PF(I)=PM(I)+2.15
       QF(I)=10096.96-(221.95*PF(I))+(.4402*YNC(I))
       QM(I)=QSS(I)-QF(I)
       PB(I+1)=((QF(I)*PF(I))+(QM(I)*PM(I)))/QSS(I)
       COST(I+1)=COST(I)*1.05
       YNC(I+1)=YNC(I)*1.05
       REGION(1,I)=PB(I+1)-1.1
       REGION(2,I)=PB(I+1)-.17
       REGION(3,I)=PB(I+1)-1.1
       REGION(4,I)=PB(I+1)
```

```
              REGION(5,I)=PB(I+1)-.6
              REGION(6,I)=PB(I+1)-1.25
              REGION(7,I)=PB(I+1)-.95
              REGION(8,I)=PB(I+1)-.8
              WRITE(6,200) I,PM(I),PF(I),PB(I+1)
        10    CONTINUE
              WRITE(6,101)
              DO 11 I=1,N
        11    WRITE(6,201) I,(REGION(J,I),J=1,8)
       101    FORMAT(1H1,5X,'YEAR',2X,'REG1',2X,'REG2',2X,'REG3',2X,'REG4',
             22X,'REG5',2X,'REG5',2X,'REG7',2X,'REG8')
       201    FORMAT(5X,I2,3X,F5.2,7(1X,F5.2))
       100    FORMAT(1H1,10X,'YEAR',5X,'MAN PRICE',5X,'FLD PRICE',
             25X,'BLEND PRICE')
       200    FORMAT(10X,I2,10X,F5.2,10X,F5.2,10X,F5.2)
              STOP
              END
//$DATA
/*END
```

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ANNEX 8

THE ECONOMIC IMPACT EVALUATION[1]

The economic impact of each alternative brucellosis program was evaluated by a three-stage procedure:

1. Base program projection
2. Alternative program projection
3. Benefit cost analysis

Following is a description of each stage.

Stage I: Base program projection.

For the base program projection, the USDA's Cross-Commodity Feed-Grain-Livestock-Wheat Model (CCFGLW)[2] was used. This is an econometric model with 165 endogenous variables representing 6 livestock sectors (Beef, Dairy, Hogs, Chicken, Turkey, and Eggs) and 6 grain sectors (Wheat, Barley, Oats, Sorghum, Corn, Soybean). There are 120 exogenous variables representing demand shifters (population, disposable income, price indices, consumption habits, etc.) and supply shifters (input prices and costs, range conditions, government programs and others).

Currently, the model is still under improvement process and has not been completely stabilized. This forced us to make our projections under nearly ceteris paribus conditions. It means, that all exogenous variables but population (based on USDA, NEAD scenarios) were kept constant at their 1979 forecasts. The endogenous acreage planted variables were replaced by the USDA, Forecast Support Group's forecasts (unpublished) for the period 1978-1988 and kept at the 1988 levels thereafter. All other portions of the model remain dynamic such that simultaneous solution for market commodity prices and quantities are calculated for the 1977-1995 year-by-year period. The method of Gauss-Seidel for iteration was modified to account for the model's nonlinearities,[2] convergence was achieved for all years for all program alternatives.

Since the historical time series data were related to the past with the enacted current national brucellosis program in force, the CCFGLW model's results represent the base program projections.

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1. This Annex was prepared by Dr. Hovav Talpaz, Assoc. Prof. of Agri. Economics, Texas A & M University.

2. Lloyd D. Teigen, "A Linked Model for Wheat, Feed Grain and Livestock Sectors of the U.S.," September 1977, USDA, ESCS, CED (Manuscript).

We are indebted to Dr. L. Teigen and Dr. C. Carman for making this model available to us and for their assistance in adapting it.

Stage II. Alternative program projections.

The procedure for making any alternative brucellosis control program was similar to the procedure for making the Base program projection discussed above with the following modification. Values representing changes in beef, veal and milk productions for each year during 1977-1995 were used as exogenous supply shifters for the corresponding supply equations in the model. These shifters were calculated by the brucellosis simulation model outlined in Annex 1. The "shifted" model was then put under the same procedural scheme for obtaining the iterative solution which resulted with a different set of prices and quantities for all livestock sectors over time, representing the particular alternative projections.

Stage III. Benefit/cost analysis.

Benefit/cost analysis was conducted based on results of the previous two stages. The criterion was based on the welfare measurement of consumers' plus producers' surplus and the cost of program implementation.

To facilitate discussion let us consider a single commodity (i.e., beef) with a linear demand and supply functions as shown in Figure 3, Chapter IV. P and Q represent the equilibrium price and quantity, respectively, for that year under the base program, P_1 and Q_1 are the corresponding price and quantities for an alternative program. The change (increase) in consumers' surplus (CCS) is given by the trapezium PP_1E_1E and calculated by

$$CCS = (P - P_1)(Q + Q_1)/2 = \Delta P(Q + Q_1)/2.$$

The change in producers' surplus (CPS) is given by the difference between the triangles P_1E_1S and PES, or

$$CPS = [(P_1 - S)Q_1/2] - [(P - S)Q/2] = \tfrac{1}{2}[P_1Q_1 - PQ + S(Q - Q_1)].$$

The point S, the intercept of the supply function, is the only variable not computed by the previous Stage I or Stage II. This is because equations in the USDA model there represent a supply response as a function of the supply and price of other commodities, not the supply curve itself. Hence, in addition to the assumption of linearity for the segment EE_1, the assumption of linearity holds for the segments SE and SE_1, and approximated values S for each commodity in the program were selected by the following formula:

$$S = VC_m(1 + r/2)^t$$

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*Ketter, R. L. and S. P. Prawel, Jr., Modern Methods of Engineering Computation, McGraw-Hill, New York, 1969, pp. 85-88.

where

VC_m = the per unit variable cost in the most efficient production region in the U.S.;

r = inflation rate (divided by 2 under the assumption that the region is retaining its comparative advantage through advantages in allocating variable inputs, such that prices of these inputs are affected by only 50 percent of the general inflation rate.

t = year minus 1976.

Note that different assumptions about S will not change the ranking between alternatives since it is a common value for all program alternatives. Also, note that only the slope (not the intercept) of the supply is assumed to shift.

The following list provides the intercept assumptions for all commodities in the calendar year 1976.

$S_{(beef)}$ = \$11.55 /cwt. Source: Livestock and Meat Stat. June 1978.

$S_{(milk)}$ = \$ 6.06 /cwt. Source: U.S. Congress Senate Committee on Agriculture and Forestry. Cost of Producing Milk in the U.S., 1975-76. Gov. Printing Office, Washington, D.C.

$S_{(eggs)}$ = 28.65¢/doz. Source: Poultry and Eggs Situation, June 1978.

$S_{(pork)}$ = \$31.19 /cwt. Source: (ESCS) Cost of Producing Hogs in the U.S. 1976.

$S_{(chicken)}$ = 15.25¢/lb. Source: Poultry and Eggs Situation, June 1978.

$S_{(turkey)}$ = 21.85¢/lb. Source: Poultry and Eggs Situation, June 1978.

$S_{(sorghum)}$ = 0.85\$/bu.*

$S_{(wheat)}$ = 1.03\$/bu.*

$S_{(barley)}$ = .87\$/bu.*

$S_{(corn)}$ = .91\$/bu.*

$S_{(oats)}$ = .50\$/bu.*

$S_{(soybean)}$ = 1.30\$/bu.*

The component of consumers' surplus related to each grain commodity was ignored, since most of these grain consumers were the producers of livestock hence these benefits were already indirectly accounted for.

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*Source: Cost of Producing Food Grain, Oilseed, and Cotton, 1974-76. ERS, USDA, Report No. 338, June 1976.

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